Atlas and Text-Book of Human Anatomy

Sobotta-McMurrich

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ATLAS AND TEXT-BOOK

OF

HUMAN ANATOMY

BY

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VOLUME II

THE VISCERA, INCLUDING THE HEART

With 214 Illustrations, Mostly in Colors

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PREFACE

The second volume of the Atlas and Text-Book of Human Anatomy is the immediate continuation of the first, and treats of the viscera and of the heart. It has seemed desirable to include the heart with the viscera since it is usually dissected in common with them and its arrangement with them in the Atlas will consequently be more convenient for the use of the student.

The selection and mode of reproduction of the dissections are identical with those employed in the first volume. Topographic anatomy as such has not been specially considered, but in many instances, particularly in the regional illustrations, the method of presentation is necessarily of a topographic character.

All the illustrations in this volume, except Figs. 365–367,* have been produced by the artist, K. Hajek, in a thoroughly praiseworthy manner. The same methods of reproduction have been employed as in the first volume, viz. autotype (partly multicolored), multicolored lithography (Figs. 328, 365–367, 416, 417, 455, 459, 460, 515, 516, and 520–523), and the three-color process (Figs. 405–410, 413, 461, 462, 518, and 519). Explanatory figures and diagrams have been reproduced by simple line-etchings. Photography has also been made the basis for all the original drawings and has been uniformly utilized for the general lines of the illustrations.

In the production of this volume even more than in that of the first, the publishers have spared neither effort nor expense to insure the greatest excellence of the illustrations.

THE AUTHOR.

*The originals of these three illustrations were drawn by the artist, A. Schmitson.

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ATLAS AND TEXT-BOOK

OF

HUMAN ANATOMY.

SPLANCHNOLOGY.

GENERAL SPLANCHNOLOGY.

The word viscera in its broadest sense includes all of the organs situated within the cavities of the body, so that the brain and spinal cord, the heart, and even some of the organs of special sense, such as the eye, might properly be described under this designation. It has, however, been customary for the systematic anatomist to include under the term only the organs contained within the visceral tube* and to consider the brain and spinal cord under neurology, the heart† under angiology, and the eye under the organs of special sense.

The organs contained within the visceral tube of the body may be grouped into three chief subdivisions: (1) the digestive apparatus; (2) the respiratory apparatus; and (3) the urogenital apparatus. The uropoietic and genital organs are usually classified together on account of their intimate topographic relations, their associated development, and their common origin (with the exception of some individual portions) from the mesoderm, and there is equal or even greater reason for regarding the digestive and respiratory organs as parts of a common apparatus, since the respiratory viscera make their appearance simply as an appendage of the digestive tract, the parts of both systems, with the exception of the anterior portion of the mouth, are derived from the entoderm, and certain portions of the digestive tract subserve also the function of respiration. In each of the three chief subdivisions, two principal constituents may be recognized, namely, a tubular canal and a series of non-tubular so-called parenchymatous organs, whose chief component is termed *parenchyma*. This is usually a soft, grayish-red or brownish mass, which constitutes the secreting epithelial substance of the glandular structures belonging to the individual apparatus, or more rarely consists of lymphatic tissue, as in the spleen.

* For a definition of this the reader is referred to the general introduction which follows the third volume.

† From a topographic standpoint the heart might also be included with the viscera, especially on account of its relation to a serous cavity.

Since the constituents of each individual apparatus are arranged about a central tubular canal we also speak of the digestive tract, the respiratory tract, and the urogenital tract. The first two may also be combined under the name of the intestinal tract and, conversely, a portion of the urogenital tract may be referred to as the genital tract. The main tubular portion of each apparatus may be spoken of in general as a mucous tract, since it is lined by a mucous membrane, the most important part of which is the epithelium which covers its surface and which alone constituted the primitive visceral tube, although it also contains the *tunica muscularis mucosæ*, a thin layer of involuntary muscle-tissue which is well developed only throughout the greater portion of the digestive tract.

In addition to the mucous membrane the tubular portions of the visceral tract also possess throughout considerable portions of their extent a *tunica muscularis*, the fibers of which are frequently arranged in several layers, in which the fibers pass usually in transverse and longitudinal directions. The mucous membrane is generally freely movable upon the muscular tunic on account of the interpolation of a layer of loose connective tissue, the *tunica submucosa*, and both this and the mucous layers may contain small glands.

(For a more minute description of the structure of the mucous membrane, etc., the reader is referred to the Sobotta-Huber "Atlas and Epitome of Normal Histology," Saunders' Medical Hand-Atlases.)

The larger glandular structures of the viscera are usually arranged as lateral appendages of the tubular portions and form the greater portion of the so-called parenchymatous organs. Their

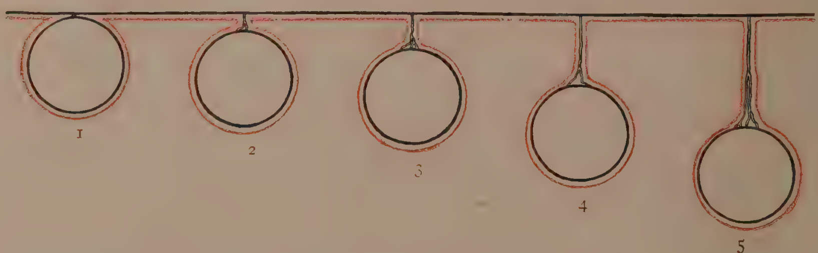

FIG. 321.—Diagram showing the relation of the viscera to the peritoneum (red): 1, A viscus which rests on the posterior abdominal wall; 2 to 5, viscera which are more or less distant from the posterior abdominal wall.

excretory ducts empty into the main tube and, like the glands themselves, are developed as diverticula from this, the secreting glandular epithelium being in direct continuity with the epithelium of the mucous membrane of the tube. In contradistinction to these glands (*glandulæ evehentes*), whose secretion is poured into the tube of mucous membrane through excretory ducts, are those which possess no excretory ducts (*glandulæ clausæ*), although some of the latter group may have possessed ducts up to a certain period in their development, as is the case with the thyroid gland.

In addition to the true epithelial glands there are also false or vascular glands, represented chiefly by the lymphatic glands (*lymphoglandulæ*), the tonsils, and the spleen. The thymus is sometimes regarded as belonging to this group, but it is developed as a true epithelial gland and only later loses its epithelial characteristics by degeneration. Other glands which belong

to the group are the superficial lymphatic structures which occur adherent to the mucous membrane of the digestive apparatus, among which are the tonsils.

(For a more minute description of the true and false glands the reader is referred to the Sobotta-Huber "Atlas and Epitome of Normal Histology," Saunders' Medical Hand-Atlases.)

The viscera may either be surrounded by the skeleton and muscles, as is the case with those of the neck, or else may lie in the large body-cavities. These contain the so-called serous cavities * or sacs, *i. e.*, closed spaces, which are developed from the primitive body cavity or cœlom. Their

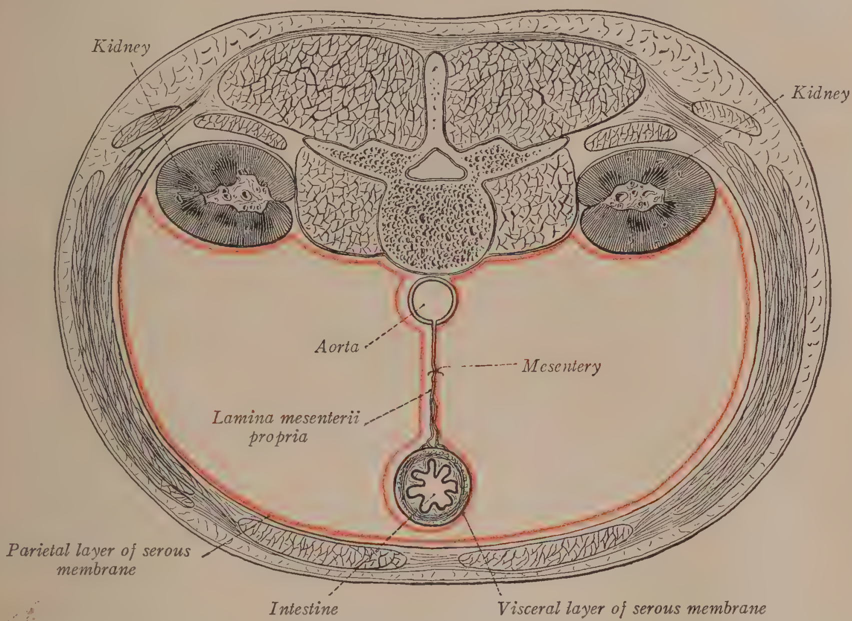

FIG. 322.—Diagram of a serous cavity.

lining membranes are covered with flat serous epithelium and are known as serous membranes (*tunicæ serosæ*).

The serous membranes are: the *peritoneum*, forming the single peritoneal cavity; the *pleuræ*, forming the paired pleural cavities; the *pericardium*, forming the single pericardial cavity; and the paired *tunicæ vaginales propriæ* (*testis*). The latter, the last formed of all the serous cavities, originate from peritoneal diverticula which accompany the testicle in its descent (see page 127), and are consequently found only in the male. The pericardium surrounds none of the actual

* The true serous cavities are lined by a serous membrane and should not be confounded with the false serous cavities, which are simply interspaces in the connective tissue. An example of the latter is furnished by the cavities in the vicinity of the central nervous system.

viscera, but contains the heart; the pleuræ envelop the two lungs; and the peritoneum invests the greater part of the digestive tract as well as a portion of the urogenital apparatus.

The general relation of the serous cavities to the viscera which they harbor is practically uniform throughout (Fig. 321). The viscera push themselves more or less deeply into the closed serous sac * so that they carry ahead of them an investment of serous membrane. There may consequently be distinguished a *parietal layer* of peritoneum which lines the abdominal walls and a *visceral layer* which provides a serous envelope for the viscera (Fig. 322). If a viscus lies freely in a serous cavity so that no portion of its surface is in contact with the body wall it is connected with this wall by a plate of connective tissue, the *lamina mesenterii propria*, which transmits its vessels and nerves, and at the junction of this lamina with the abdominal wall the parietal layer of the peritoneum becomes continuous with the visceral layer (Fig. 322). The structure formed in this manner, and consisting of the lamina mesenterii propria covered on either side by serous membrane, is termed a *mesentery*.

According to the distance of the viscus from the abdominal wall the mesentery is long or short, and the particular viscus is correspondingly more or less movable. This is the relation held by the different portions of the intestine to the abdominal wall. Upon the other hand, the viscus may project but slightly into the serous cavity, so that it is applied to the body wall by a broad surface which remains entirely free from serous investment (Fig. 321, 1); this is the case with the adult kidney (Fig. 322). Between these two conditions every possible stage of transition occurs. Sometimes the visceral serous coat is intimately adherent to the surface of the viscus,† forming its *tunica serosa*, and in other cases the two structures are separated by a layer of loose areolar tissue, the *tunica subserosa*, which usually contains fat.

The serous surfaces of the viscera invested by serous membrane are in such close contact with each other and with the parietal layer that only capillary spaces remain, and these are filled by a very small quantity of serous fluid.

In the individual sections upon Special Splanchnology those organs which possess topographic and functional relations to the system under discussion will also be considered, so that the spleen will be described with the organs of digestion and the suprarenal bodies with the urinary apparatus.

One of the first organs to be laid down in the embryo is the intestinal tract, which arises by a folding of the entoderm, eventually transformed into a tube. This soon enters into relation with the primitive body cavity or cœlom, which originates as two cavities, one on either side of the middle line, between the so-called lateral plates of the mesoderm, the two cavities subsequently fusing to form a single one. From the primitive intestinal tract are formed all the organs of the digestive and respiratory tracts, while the urinary and genital organs are laid down separately, although in the human embryo, as in the adults of almost all the vertebrates except the higher mammals, they terminate posteriorly in a cavity, the cloaca, which also receives the termination of the primitive intestine (see page 126). For a certain period therefore, even in the human embryo, all the true viscera are connected in the posterior portion of the body.

* In the female the peritoneal cavity is not completely closed, but is in communication with the cavity of the female sexual apparatus.

† This adherence is most complete in the ovary, where the serous epithelium of the peritoneum becomes directly continuous with the so-called germinal epithelium of the ovary and the connective-tissue layer of the peritoneum simply passes into the ovarian stroma.

SPECIAL SPLANCHNOLOGY.

THE DIGESTIVE APPARATUS.

The digestive apparatus (Fig. 323) includes the actual intestinal tract, taking those words in their widest sense, and according to its development this tract may be divided into four portions: (1) The oral cavity; (2) the foregut; (3) the midgut; (4) the hindgut. The oral cavity extends from the lips to the isthmus of the fauces; the foregut comprises the pharynx, the œsophagus, and the stomach; the midgut is identical with the small intestine; and the hindgut is composed of the large intestine and the rectum. The tract commences at the mouth and terminates at the anus.

Associated with the digestive tube are a large number of glandular appendages, namely, the small and large salivary glands in the mouth; the pharyngeal, œsophageal, and gastric glands in the foregut; and the duodenal and intestinal glands, as well as the two largest glands of the digestive apparatus, the pancreas and the liver, in the midgut. The hindgut has only the intestinal glands situated in its walls. Although the spleen is not really an organ of the digestive tract, since it originates in the mesenchyma and not from the entoderm, it is usually described with the digestive apparatus. The wall of the digestive tube also contains lymphatic aggregations of variable size, whose chief peculiarity is that their parenchyma is adherent to the superficial epithelium of the gut, which thus becomes infiltrated by their cellular elements. In the upper portion of the tract the larger of these aggregations are designated as *tonsils*, in the lower portion as *aggregated lymphatic follicles* (Peyer's patches).*

For a certain period in the human embryo the gut is a completely closed straight tube possessing neither an oral nor an anal opening. These orifices are formed later, when the tract has undergone further differentiation, as oral and anal ectodermic depressions which deepen and gradually approach the anterior and posterior portions of the intestinal tube, until the lumen of the tube is separated from the outer world only by thin membranes, known respectively as the pharyngeal and anal membranes. With the rupture of these membranes the two primary body openings are formed, from which are soon developed by the formation of septa the oral and nasal cavities upon the one hand and the anal and urogenital orifices upon the other. The oral depression forms a considerable portion of the subsequent oral cavity, which is consequently very largely of ectodermic rather than of entodermic origin.

THE ORAL CAVITY.

The oral cavity is the first portion of the entire digestive tract. It is an irregularly shaped, elongated cavity, situated in the lower portion of the face, and its boundaries are partly bony and partly musculocutaneous. It is divided by the two rows of teeth into two incompletely separated spaces, the *vestibulum oris* and the oral cavity proper.

THE VESTIBULUM ORIS.

The *vestibulum oris* (also termed the *buccal cavity*) (Figs. 326, 327, and 328) is a narrow, somewhat semicircular space situated between the cheeks and lips and the teeth. When the

* The true lymphatic glands, which are found in the vicinity of the digestive apparatus, will be considered in the section upon Angiology.

FIG. 324.—The mouth, chin, and nasal region seen from in front.

FIG. 325.—The labial glands seen from behind, the mucous membrane having been removed.

FIG. 326.—View of the oral cavity from in front.

The cheeks have been divided for some distance outward from the angles of the mouth; the jaws are widely separated; and the lips are everted.

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upper and lower teeth are in apposition it communicates with the oral cavity proper behind the last molar tooth, and it communicates with the outer world through the oral orifice (*rima oris*).

This is bounded by the *lips* (Fig. 324), which are connected at the angles of the mouth by the *labial commissures* and form the greater portion of the anterior wall of the vestibule. The upper lip is longer than the lower and its external surface presents a rather broad, shallow, median furrow, known as the *philtrum*, which runs downward toward the vermilion border and terminates in the *tubercle* of the upper lip. The upper lip is separated from the cheek by the *nasolabial groove*, which passes outward and downward in a slight curve from the ala of the nose. The outer surface of the lower lip is traversed by the *mentolabial groove*, a transverse furrow which separates it from the chin.

The lips are composed of the skin, the labial muscles (see Vol. I, page 180), and the labial mucous membrane, the last containing the *labial glands* (Fig. 325), which are mucous glands varying in size from that of a lentil to that of a small pea.

The posterior surfaces of the lips are connected with the mucous membrane (*gingiva*) covering the alveolar processes of the maxillæ and mandible by thin folds of mucous membrane known as the frenula of the lips (Fig. 326). The frenulum of the upper lip is always longer and more distinct than that of the lower.

Laterally from the lips the cheeks (*buccæ*) form the external boundaries of the vestibulum oris (Fig. 326). Like the lips, they consist of integument (with large hairs in the male), of muscles (see Vol. I, p. 180), and of mucous membrane which in this situation is thin and contains the *buccal glands* (Fig. 325) partly embedded in the buccinator muscle (see Vol. I, p. 181) or even lying upon its outer surface. In the angle between the buccinator and masseter muscles (see Vol. I, p. 183) is situated a marked accumulation of fatty tissue, the *buccal fat mass*.

The portion of oral mucous membrane which envelops the alveolar processes and passes between the teeth to be attached to the interalveolar septa is of considerable thickness and is known as the gum or *gingiva* (Fig. 329). It is firmly attached to the periosteum by its submucous layer and is distinguished from the remainder of the oral mucous membrane by its firm structure.

The posterior wall of the vestibulum oris is formed by the alveolar processes enveloped by the oral mucous membrane and by the anterior or anterolateral teeth.

The buccal mucous membrane also presents the orifice of the parotid duct (see page 38).

THE ORAL CAVITY PROPER.

The oral cavity proper (Figs. 326, 327, and 328) is bounded above by the *palate*, which separates it from the nasal fossæ. Its floor is formed chiefly by the tongue (see page 34), which, when the mouth is closed, practically fills the cavity, only a relatively small space remaining

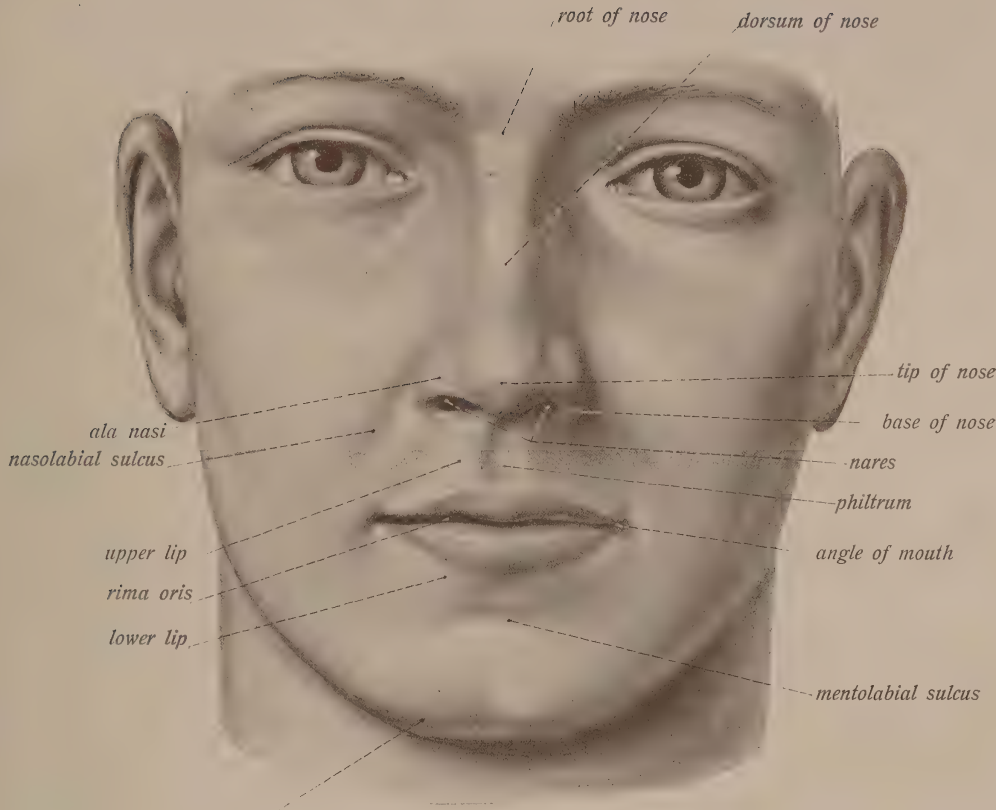

Fig. 324.

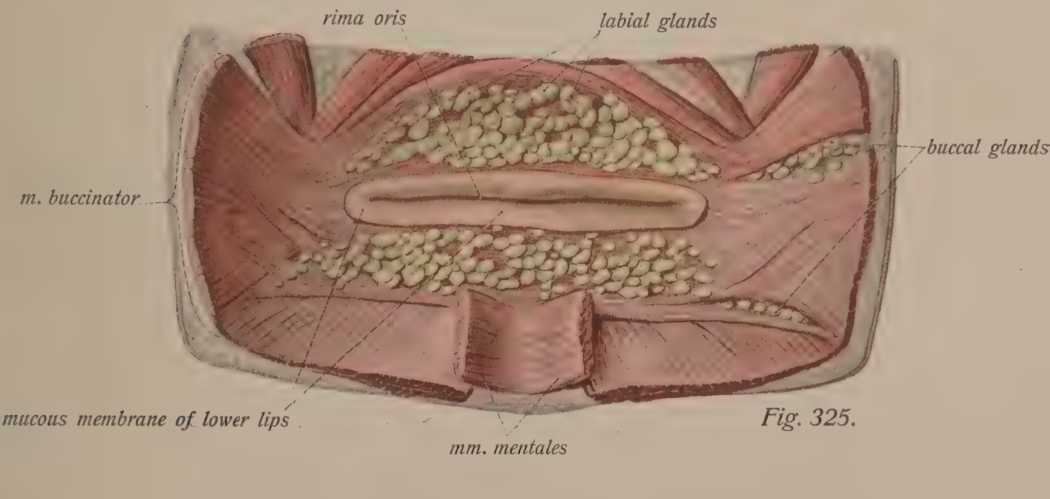

Fig. 325.

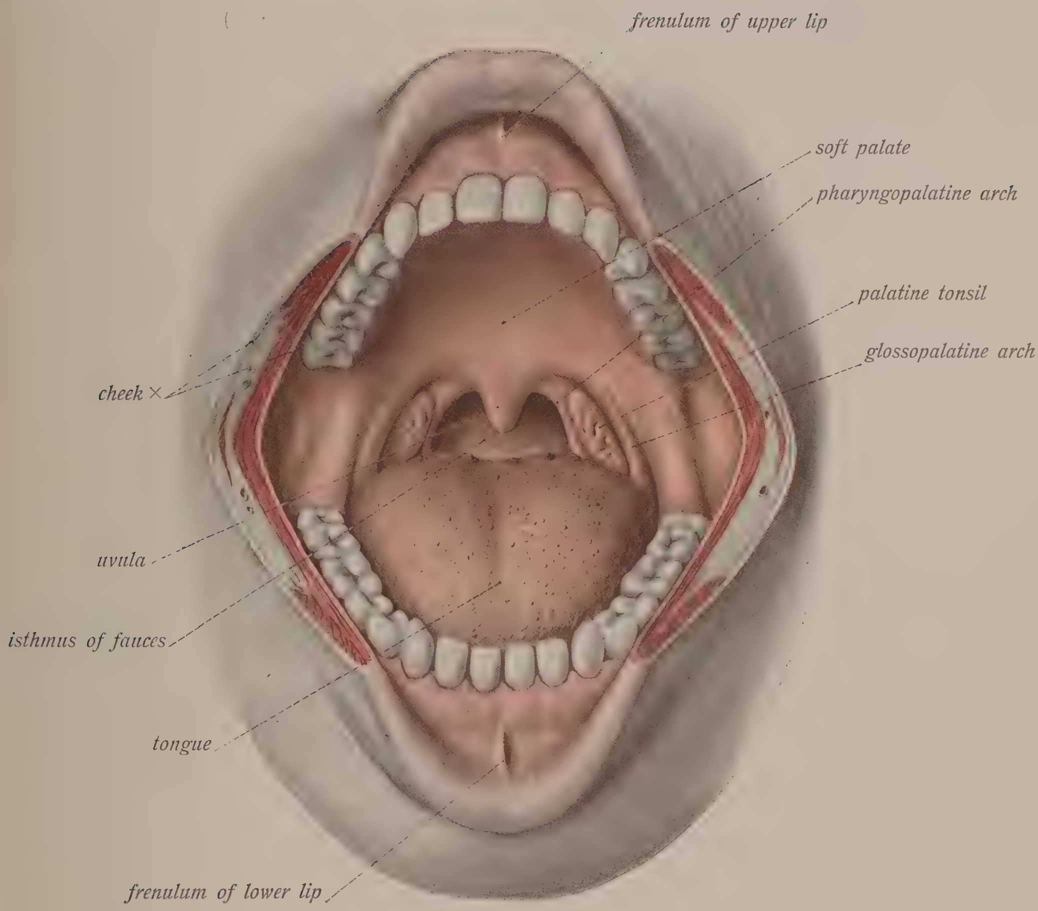
frenulum of upper lip
soft palate
pharyngopalatine arch
palatine tonsil
glossopalatine arch
cheek ×
uvula
isthmus of fauces
tongue
frenulum of lower lip

Fig. 326.

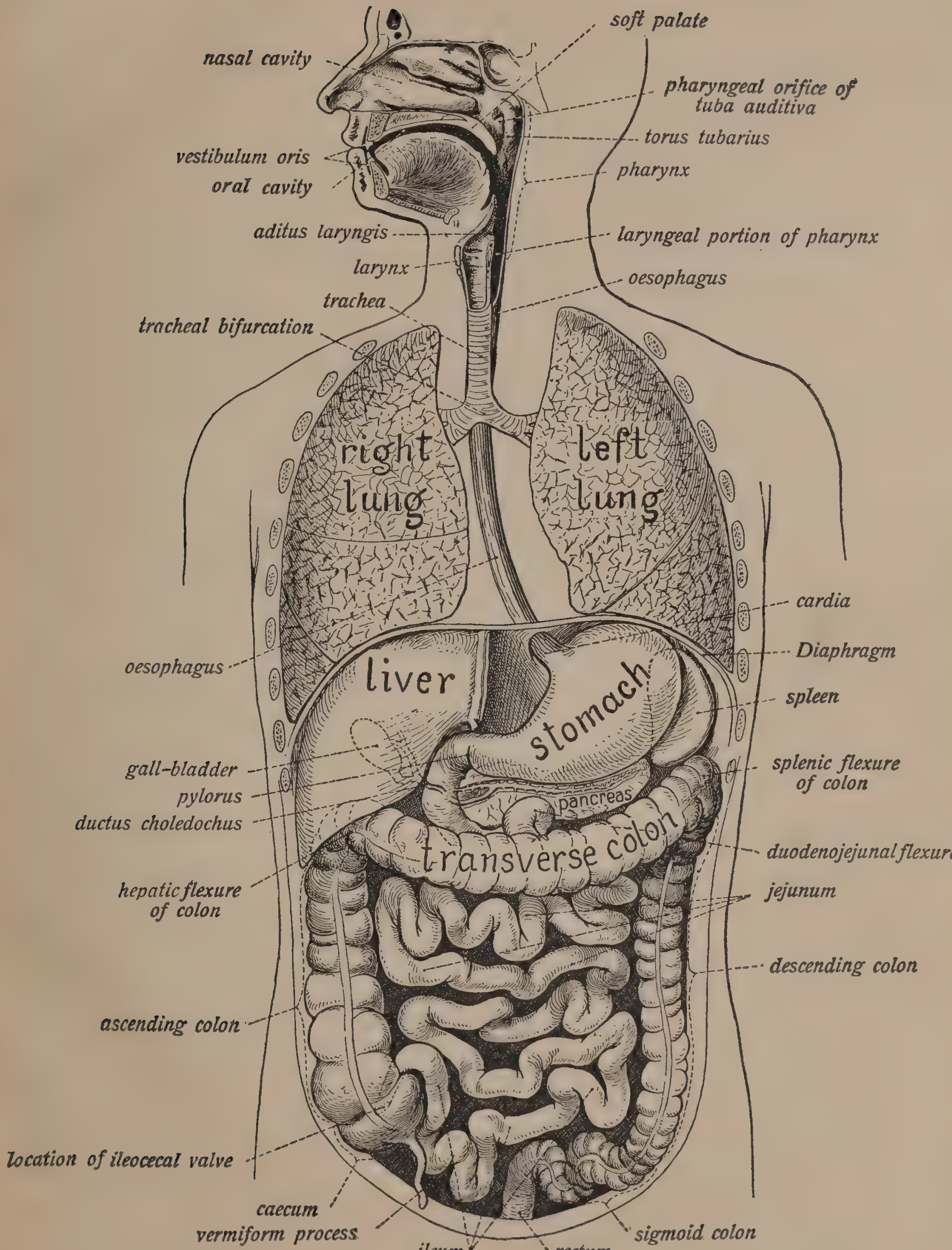

FIG. 323.—Diagram showing the arrangement of the digestive and respiratory organs.

FIG. 327.—View of the oral cavity and palate after dividing the cheeks.

The mucous membrane of the palate has been partly removed on the right side to show the palatine glands and on the left side the glands have been removed to show the interlacing of the muscles of the velum palatinum (*).

FIG. 328.—A median sagittal section of the viscera of the head and neck.

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between the dorsum of the tongue and the palate. The anterior and lateral boundaries are formed by the dental arches, while posteriorly the cavity is only partly bounded by the velum palatinum and the palatine arches, since it communicates in this direction with the pharynx through the *isthmus of the fauces.*

The *palate*, the roof of the oral cavity (Figs. 327 to 330), is further divided into the *hard* and the *soft palate.* The former accurately corresponds to the relief of the hard palate of the skeleton (see Vol. I, p. 78), and its mucous membrane is thick and firm, like that of the gums, and is intimately connected with the periosteum by strong submucous fasciculi. It contains many mucous *palatine glands* which are of irregular shape and vary in size from 2 to 5 mm.

In the median line the mucous membrane of the hard palate forms a slightly elevated palatine raphe, the anterior extremity of which terminates in a small, rounded, wartlike projection, the *incisive papilla*,* which corresponds to the position of the incisive foramen. Anteriorly it also presents three or four transverse palatine folds or *rugæ* (Figs. 327 and 329), the development of which is subject to considerable variation.

The *soft palate* or *velum palatinum* (Figs. 326 to 328 and 329) is a muscular plate, richly supplied with glands and covered upon both surfaces by mucous membrane (see page 41), which separates the oral cavity from the nasal portion of the pharynx. It hangs obliquely downward and backward, its base being attached to the posterior border of the bony palate and its anterior surface directly continuous with the mucous membrane of the hard palate. At either side it is continuous with the palatine arches which form the lateral boundaries of the fauces and it terminates below and behind in a round conical appendage, the *uvula*, whose tip, when its muscles are at rest, is curved forward. The anterior surface of the soft palate is concave and directed toward the oral cavity, the posterior is convex and looks toward the pharynx. The mucous membrane of the soft palate is fairly smooth, although it is thrown into slight folds by the relaxation of the muscles; it is thinner than that of the hard palate and contains a much greater number of mucous *palatine glands* (Fig. 327), which are also larger and more closely crowded together. The lateral portions of the soft palate constitute the two *palatine arches*, two folds of mucous membrane containing muscles, which form the lateral boundaries of the isthmus of the fauces (Fig. 326). (See also page 41.)

The more anterior fold, the *glossopalatine arch*, passes in a curve from the lower margin of the soft palate to the mucous membrane of the lateral border of the tongue, where it broadens somewhat and terminates as the *plica triangularis* (Fig. 351). The posterior or *pharyngopalatine arch* is thicker and straighter than the anterior one and extends between the soft palate and the outer wall of the oral portion of the pharynx.

* The incisive papilla not infrequently exhibits in its center one small or sometimes a paired pit-like depression, the remains of the incisive duct (see page 89).

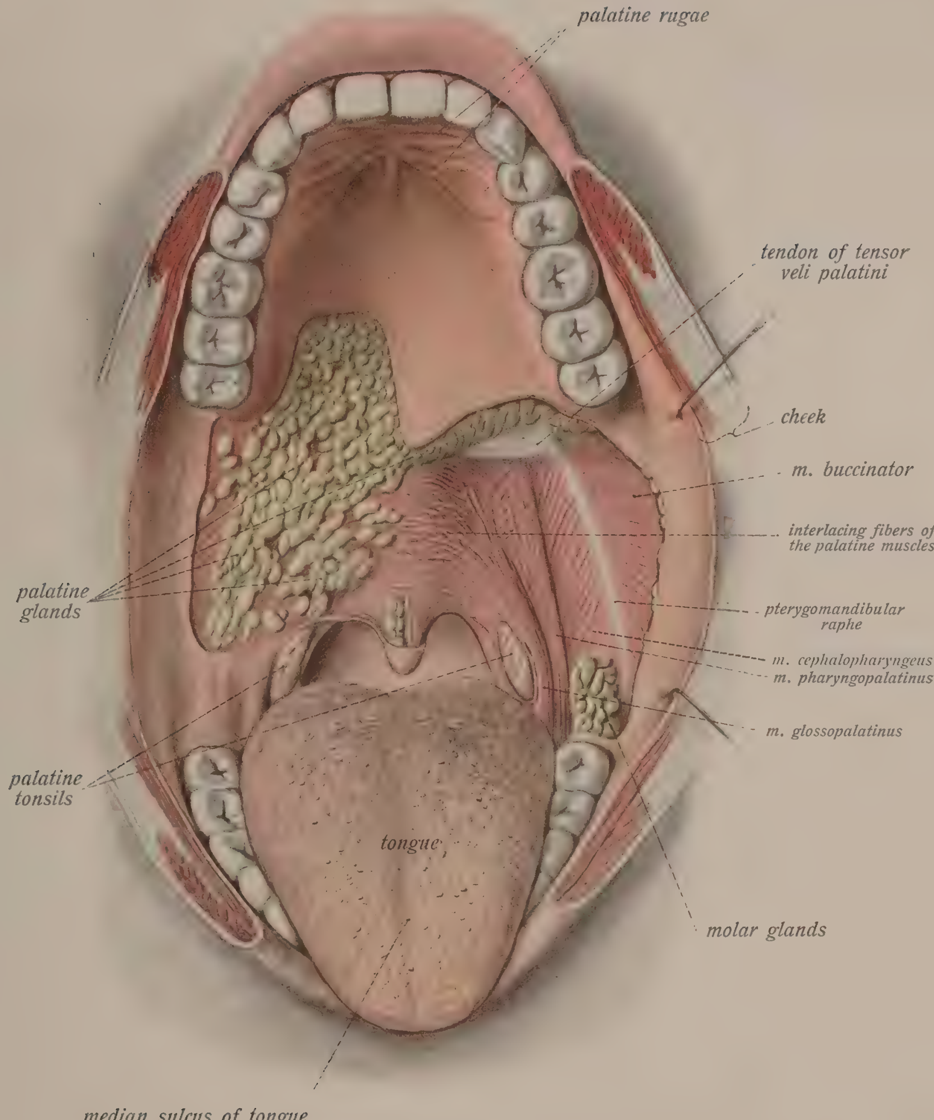
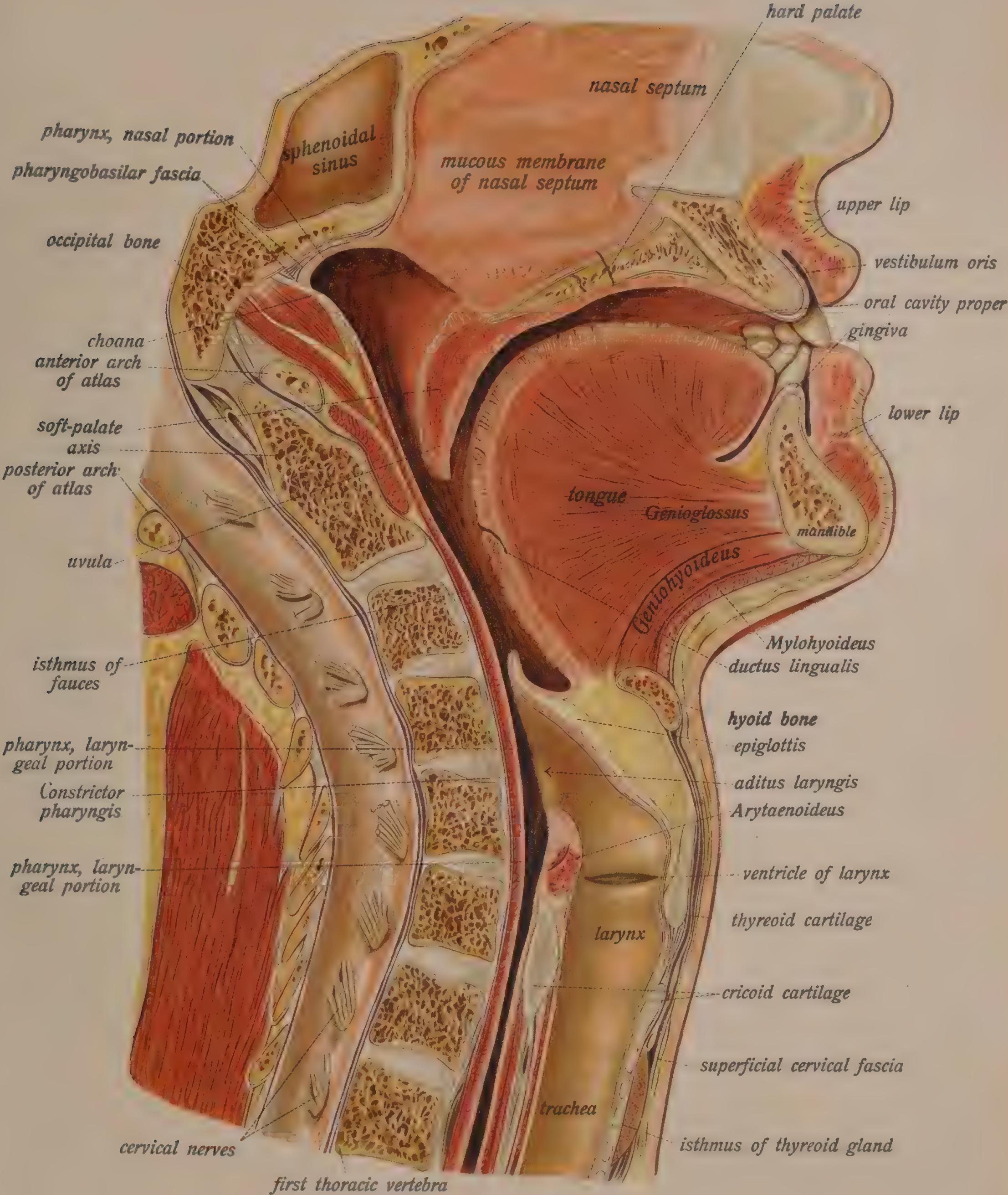

palatine rugae
tendon of tensor veli palatini
cheek
m. buccinator
interlacing fibers of the palatine muscles
palatine glands
pterygomandibular raphe
m. cephalopharyngeus
m. pharyngopalatinus
m. glossopalatinus
palatine tonsils
tongue
molar glands
median sulcus of tongue

Fig. 327.



hard palate
nasal septum
pharynx, nasal portion
sphenoidal sinus
pharyngobasilar fascia
mucous membrane of nasal septum
upper lip
occipital bone
vestibulum oris
oral cavity proper
choana
gingiva
anterior arch of atlas
soft-palate
lower lip
axis
posterior arch of atlas
tongue
Genioglossus
mandible
uvula
Geniohyoideus
Mylohyoideus
isthmus of fauces
ductus lingualis
hyoid bone
pharynx, laryngeal portion
epiglottis
aditus laryngis
Constrictor pharyngis
Arytaenoideus
pharynx, laryngeal portion
ventricle of larynx
thyreoid cartilage
larynx
cricoid cartilage
superficial cervical fascia
trachea
cervical nerves
isthmus of thyreoid gland
first thoracic vertebra

Fig. 328.

Between the palatine arches upon either side is found the *tonsillar sinus*, in which is situated the *palatine tonsil* (Figs. 326, 327, 363, and 364), a somewhat flat, oblong elevation upon the surface of which deep fissures or depressions, the *fossulæ tonsillares*, are visible. Its borders are not very sharply circumscribed, but it fills more or less completely the space between the two palatine arches.* Just above the tonsil there is frequently a deep triangular pit, the *supratonsillar fossa*, which is believed to be the remains of the second pharyngeal pouch of the embryo. It contains the orifices of mucous glands which are everywhere so plentiful in the tonsillar region.

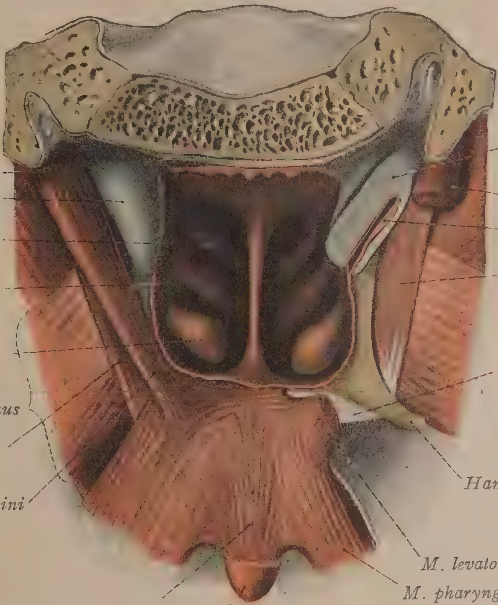


FIG. 329.—The palatine muscles seen from behind. On the right side the levator veli palatini has been removed and the tuba auditiva has been opened up. The mucous membrane has been cut at the margins of the choanæ.

Both the soft palate and the palatine arches contain muscles which are termed the palatal and pharyngeal muscles. They are the following:

The *azygos uvulæ* (*m. uvulæ*) is a small, unpaired, flat, elongated muscle which arises from the posterior nasal spine and terminates in the apex of the uvula, being situated nearer its posterior than its anterior surface. It not infrequently shows indications of being a paired muscle.

The *levator veli palatini* (*petrosalpingostaphylinus*) (Figs. 329 and 367) is a rather flat,

* The tonsillar tissue may not only entirely fill the tonsillar sinus but also extend upon the palatine arches, in which case the margins of the arches are not visible. The development of the palatine tonsil is subject to great individual variation.

FIG. 330.—The palate with the superior dental arch seen from below, showing the masticatory surfaces of the teeth and orifices of the palatine glands (*).

FIG. 331.—The inferior dental arch seen from above, showing the masticatory surfaces of the teeth.

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elongated, paired muscle which arises from a rough area near the carotid foramen upon the inferior surface of the petrous portion of the temporal bone (see Vol. I, p. 56), and from the lower margin of the posterior extremity of the cartilaginous portion of the tuba auditiva. It passes downward and inward in the outer wall of the nasal portion of the pharynx (see page 42) to the soft palate, where it spreads out in a flat lamina, the fibers of which interlace with those of the opposite muscle and with the pharyngopalatinus and azygos uvulæ (Fig. 327), forming with these muscles an almost continuous muscular plate, situated nearer the posterior than the anterior surface of the soft palate, being separated from the latter surface by a thick mass of glands.

The *tensor veli palatini* (*sphenosalpingostaphylinus*) (Figs. 329, 365, and 367) is a thin, flat, elongated muscle which arises by a short tendon from the spine of the sphenoid, from the scaphoid fossa of the internal pterygoid process, and from the outer wall of the cartilaginous tuba auditiva. It is intimately related with the internal surface of the pterygoideus internus, from which it is separated only by the buccopharyngeal fascia (Vol. I, p. 184). The levator veli palatini is more internal and further posterior than the tensor veli palatini, from which it is separated by fatty tissue.

Above the hamular process of the internal pterygoid plate the posterior surface of the muscle passes into a narrow tendon which winds around the hamular process in the sulcus hamuli and broadens out into an aponeurosis which passes almost horizontally across the soft palate to join its fellow of the opposite side. A small bursa, the *bursa m. tensoris veli palatini*, separates the tendon from the bone. The aponeurosis formed by the tendons of the two tensores veli palatini is attached to the posterior margin of the bony palate and is situated in front of the radiating fibers of the levatores.

The *glossopalatinus* (Figs. 327 and 352) is a flat muscular bundle which forms the anterior palatine arch. It arises from the transverse fibers of the tongue and inserts into its fellow of the opposite side in the base of the uvula, being also connected with the radiations of the levator veli palatini.

The *pharyngopalatinus* (Figs. 327 and 365) is better developed than the preceding muscle and forms the posterior palatine arch. It has manifold connections with the constrictors of the pharynx and may consequently be regarded as one of the pharyngeal muscles (see page 43). A portion of it comes directly from the constrictor medius and the remainder takes origin from the posterior margin of the thyreoid cartilage in connection with the inferior constrictor. In the soft palate the muscle has relations similar to those of the glossopalatinus and is particularly intimately connected with the radiation of the levator veli palatini.

The tensor veli palatini is innervated from the third division of the trigeminus through the otic ganglion; the remaining muscles are supplied from the pharyngeal plexus by fibers from the spinal accessory and pneumogastric nerves. The levator veli palatini and pharyngopalatini constrict the isthmus of the fauces.

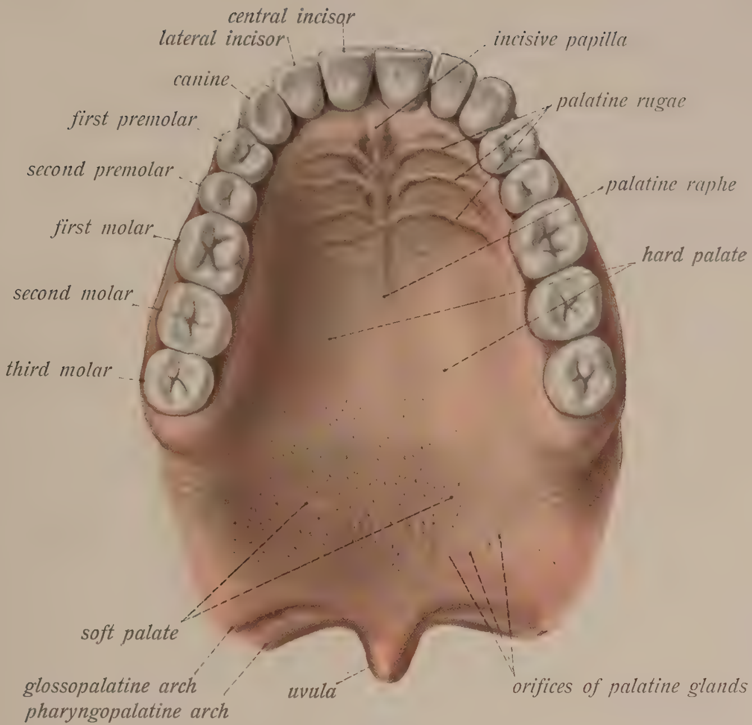

Fig. 330.

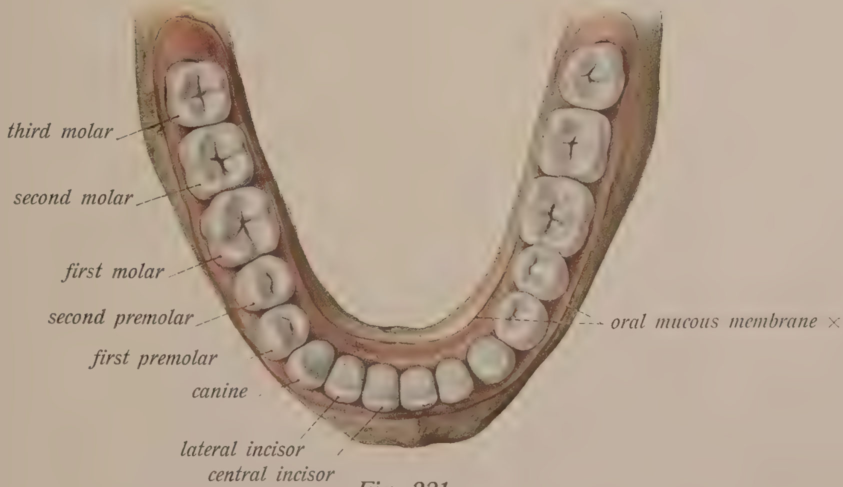

Fig. 331.

The oral mucous membrane varies in character and thickness in different localities. In the floor of the mouth, in the sublingual region, it is thin and is separated from the underlying tissue by a loose submucous layer. In the gums and hard palate it is especially thick, and the submucous layer in these situations is firmer and immovably connects the membrane with the periosteum. It is also thick upon the dorsum of the tongue, beneath which the submucosa becomes the lingual fascia (see page 34).

A considerable portion of the oral cavity is developed from the so-called oral invagination (see page 21), an ectodermal invagination which is at first separated from the endodermal intestinal tube by the pharyngeal membrane. At a certain period of development the oral invagination represents both the future oral and nasal cavities, but after the disappearance of the pharyngeal membrane and the union of the invagination with the anterior portion of the primitive gut, the oral and nasal cavities are separated by the paired palatal plates which develop from the superior maxillary processes and fuse in the median line. The lips are formed anteriorly during the formation of the face from the maxillary and mandibular processes of the first visceral arch.

THE TEETH.

The teeth (Figs. 330 to 349) are hard conical structures, whose roots are embedded in the alveoli of the jaws. The portion of the tooth surrounded by the gums is called the *neck* (*collum dentis*), while the portion projecting into the oral cavity is designated as the *crown* (*corona dentis*). The three chief constituents of a tooth are the *enamel* (*substantia adamantina*), the *dentine* (*substantia eburnea*), and the *cement* (*substantia ossea*) (Fig. 332). The enamel is found only in the crown, while the cement is present chiefly about the root, although it forms a very thin layer about the neck of the tooth, where the enamel and the dentine become thinner. The enamel has a white glistening surface with a bluish or yellowish shimmer, while the root of the tooth is slightly yellowish and dull.

In the crown of each tooth there may be recognized a masticatory surface directed toward its fellow in the opposite jaw, a labial or buccal surface directed toward the lip or the cheek respectively, a lingual surface in relation with the tongue, and two contact surfaces in apposition with the neighboring teeth.

The root of the tooth is single or multiple and is generally conically shaped (Fig. 332). At its apex is a foramen, the external orifice of the canal of the root, which extends throughout the length of the root, and in the region of the neck gradually dilates to a large cavity situated within the crown, the tooth cavity, also known as the *pulp-cavity* because it is filled by a soft non-calcified tissue, the dental pulp. The shape of the pulp-cavity is in general a reproduction of that of the entire tooth, but it not infrequently presents fine irregular ramifications.

The entire set of teeth (Figs. 330 and 331), thirty-two in number in the adult, is known as the denture, and is arranged in an upper and a lower row, the *superior* and the *inferior dental arch*. The upper row is fixed in the alveoli of the superior maxilla and the lower row in those of the mandible, the form of articulation being that known as gomphosis. The bone and the tooth are separated by a thin layer of tissue common to both structures, the alveolar periosteum (Fig. 332), which in the vicinity of the neck of the tooth is also designated the *circular ligament*. The teeth of the two rows resemble each other in shape and size, although the similarity is not absolute, and the number of teeth in each row is the same, namely, sixteen.

The teeth of each jaw are divided into four different groups according to their shape, the

incisors, the *canines*, the *premolars*, and the *molars*, and each of the four varieties possesses such well-defined characteristics that transitional types do not occur, although differences are observed

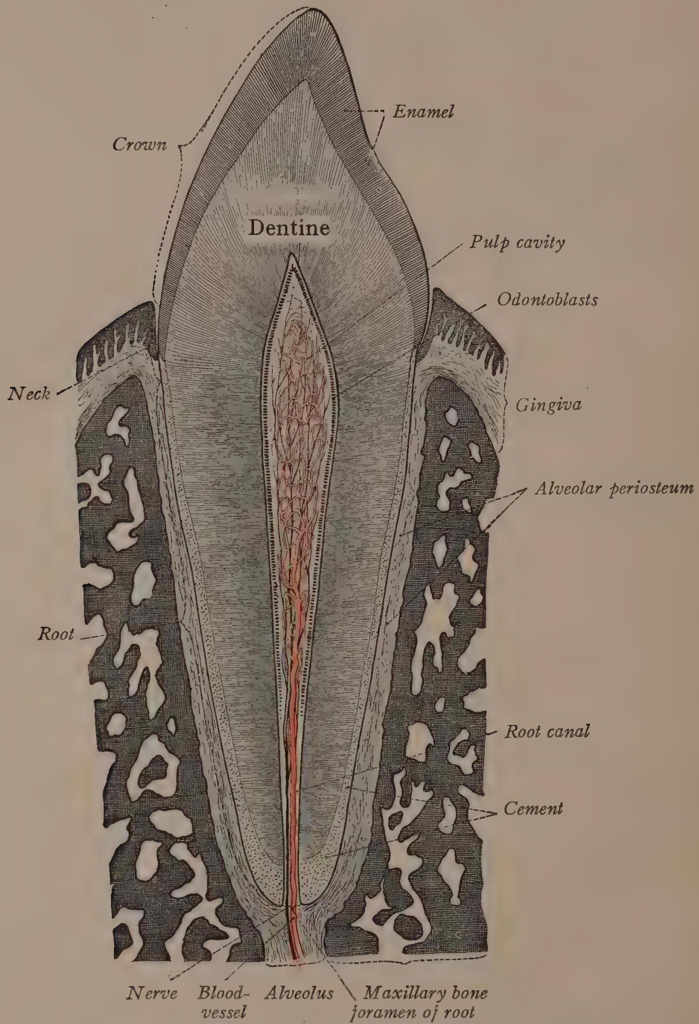

FIG. 332.—Longitudinal section of a tooth in its alveolus (diagrammatic).

between individual teeth of the same group, particularly between those of the upper and lower jaw.

In each jaw there are four incisors, two canines, four premolars and six molars, the arrange-

ment of the individual groups being the same in both jaws. The incisors are placed most anteriorly, the two central ones being in contact in the median line; then come on either side a canine, two premolars, and three molars, these last being situated most posteriorly.

The human dental formula is consequently as follows:

$$\begin{array}{cccccccccc} \text{M.} & \text{Pm.} & \text{C.} & \text{I.} & : & \text{I.} & \text{C.} & \text{Pm.} & \text{M.} & \\ 3 & 2 & 1 & 2 & : & 2 & 1 & 2 & 3 & \\ \hline 3 & 2 & 1 & 2 & : & 2 & 1 & 2 & 3 & = 32 \end{array}$$

The *incisor teeth* (Figs. 333 to 337) have flat, chisel-shaped crowns, convex on the labial surface and concave on the lingual surface, and thicker but narrower at the base and broader and thinner at their free margins. Upon the labial surface are three longitudinal ridges which are not always distinctly marked, and upon the cutting-edge of a recently erupted tooth these ridges terminate as small projections which rapidly disappear as a result of attrition. The inner corners of the cutting-edge are usually sharper than the outer ones, these being generally rounded off.

The crowns of the incisors lie in the frontal plane and present an inner and an outer surface of contact. The roots are rounded, of average length, and usually exactly straight; those of the lateral incisors are somewhat shorter and slightly flattened.

The upper incisors are always larger than the lower, and the upper central incisor is always larger than the lateral, but in the lower jaw this relationship is reversed. The relative size of the incisor teeth is subject to marked individual variations.

The *canine teeth* (Figs. 333 to 336) are situated between the incisors and the premolars and are of an elongated conical form. Their large, thick, irregularly conical crowns are approximately in the frontal plane, so that they present a labial and a lingual surface, and an inner and an outer surface of contact. The labial surface is markedly convex, and the lingual is characterized by a slight elevation. The roots are very long and conical, although they are distinctly flattened, particularly in the lower jaw. In consequence of their long roots the canines are the longest teeth of the entire dentition, and, moreover, their crowns are higher than those of the other teeth. The cusp of the crown is blunt and not exactly in the middle of the tooth, but somewhat nearer its inner side.

The *premolars* (Figs. 333 to 336) are characterized by bicuspid crowns which are flattened from before backward, and consequently present an anterior and a posterior contact surface, a convex lingual surface, and a larger convex buccal surface. The cusps or tubercles are separated by an almost sagittal groove (Figs. 329 and 330) in such a manner that the lingual cusp is smaller than the buccal one; indeed, the lingual cusp of the lower first premolar is usually poorly developed, but that of the lower second premolar is usually double, so that this tooth, which is usually the largest of the premolars, is frequently tricuspid.

The roots of the lower premolars are always single, of medium length, and distinctly flattened. Those of the upper premolars vary considerably; that of the first is usually double or at least bifid, while that of the second is generally markedly flattened or furrowed and usually possesses a double root canal.

FIG. 333.—The upper and lower teeth seen from the labial or buccal surface.

c, Canine; *in*, incisor; *i*, inferior; *l*, lateral; *m*, medial; *mo*, molar; *pr*, premolar; *s*, superior.

FIG. 334.—The upper and lower teeth seen from the lingual surface.

FIG. 335.—The upper and lower teeth seen from their contact surfaces.

FIG. 336.—The complete deciduous dentition of a three-year-old child, seen from the labial or buccal surface.

c, Canine; *d*, deciduous; *i*, inferior; *l*, lateral; *m*, medial; *mo*, molar; *pr*, premolar; *s*, superior.

FIG. 337.—The lower lateral deciduous incisor, the lower deciduous canine and the two lower deciduous molars of a two-year-old child. The teeth of the upper row are seen from their labial or buccal surfaces, those of the lower row from the same surface and at the same time from below. The roots are not yet completely ossified and represent four stages of development.

FIG. 338.—Upper and lower teeth of the skull of a twenty-eight-year-old man in their normal position.

FIG. 339.—Dentition of a child in the first year. The imperfect teeth which have not yet broken through have been exposed by chiseling away the anterior alveolar wall.

FIG. 340.—Deciduous dentition of the upper jaw of a four-year-old child.

FIG. 341.—Deciduous dentition of the lower jaw of a four-year-old child.

FIGS. 342 and 343.—Skull of a five-year-old child with the deciduous and permanent teeth seen from in front. The permanent teeth and the roots of the deciduous ones have been exposed by chiseling away the anterior alveolar wall.

All the *molars* (Figs. 333 to 335) possess a number of cusps and roots, and their crowns are low and characterized by their large circumference. The number of the roots and the position of the cusps are different in the upper and lower jaw, the upper molars being usually somewhat

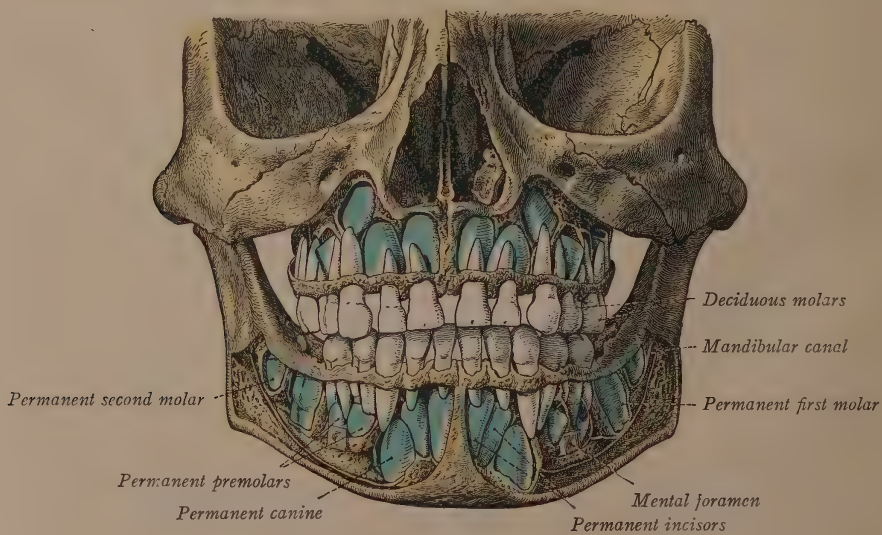

FIG. 343.

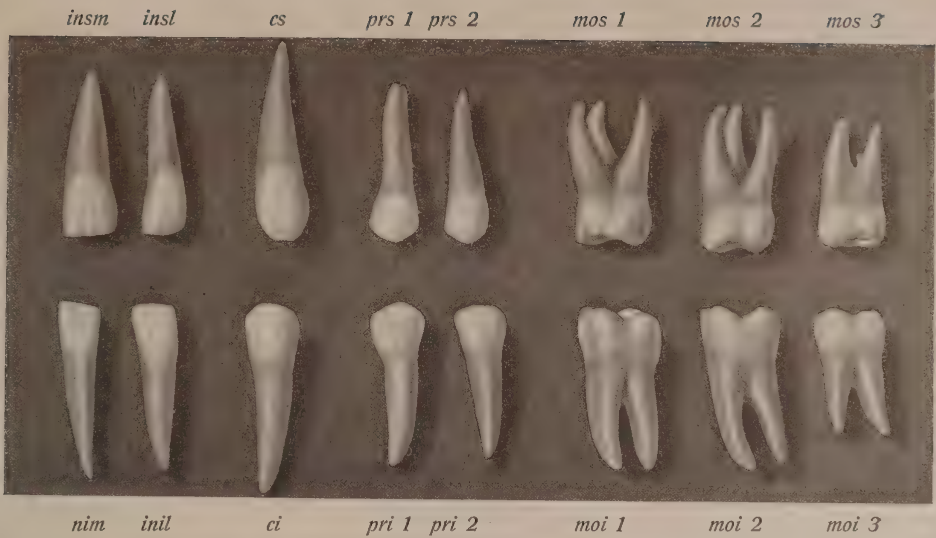

Fig. 333.

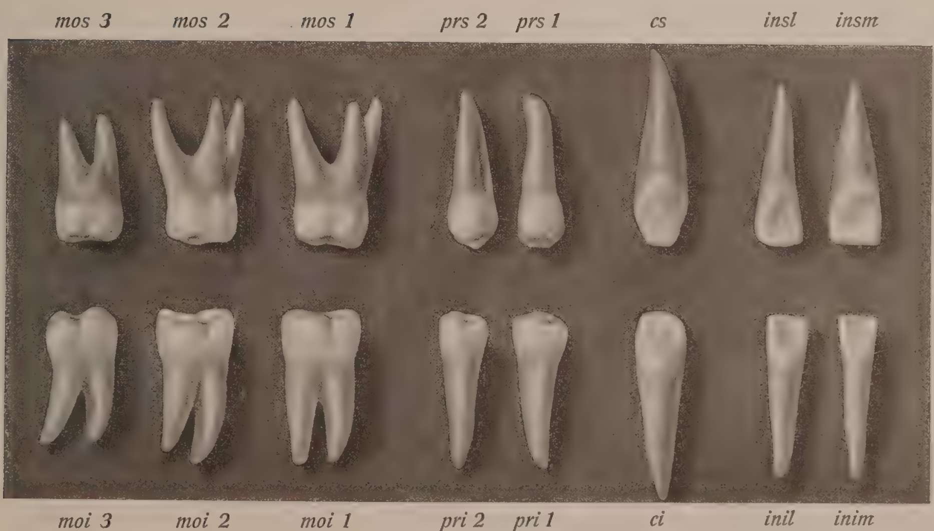

Fig. 334.

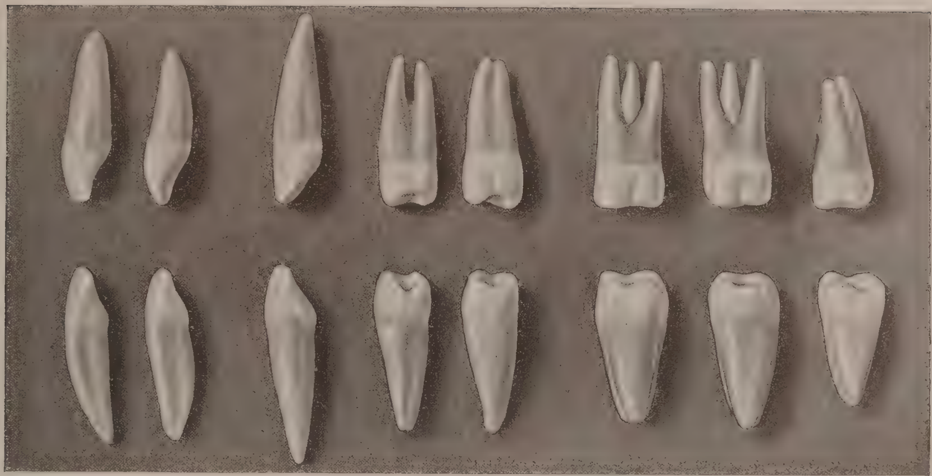

Fig. 335.

Fig. 336.

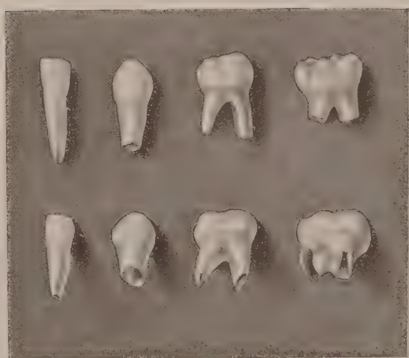

Fig. 337.

Fig. 338.

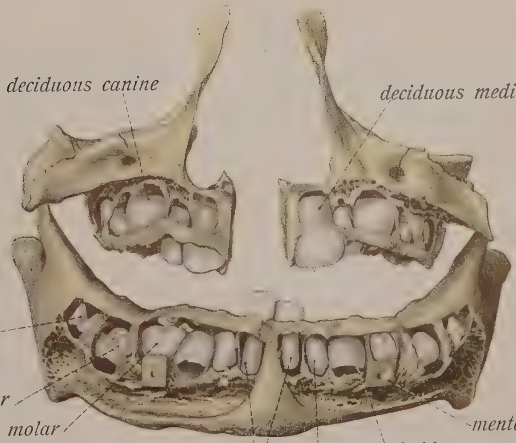

Fig. 339.

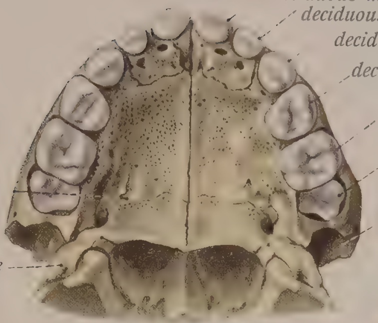

Fig. 340.

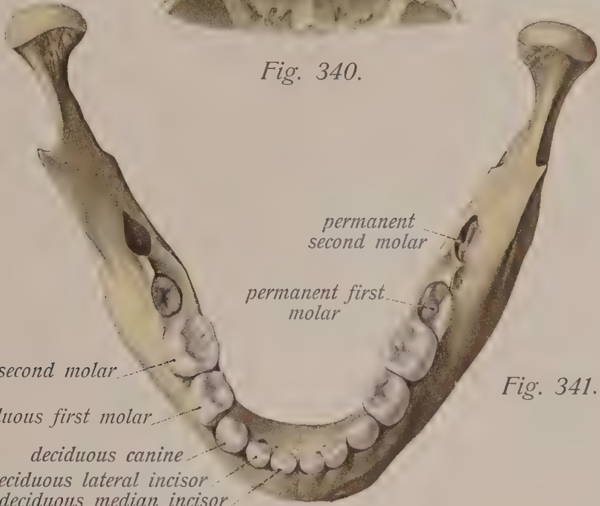

Fig. 341.

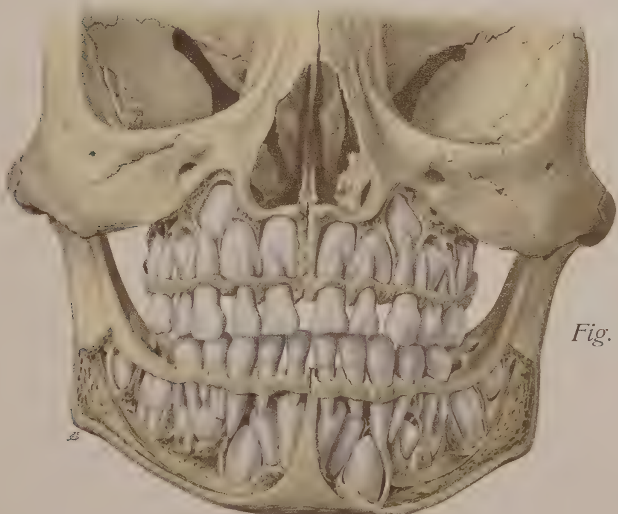

Fig. 342.

smaller than the lower and having three roots, while the lower ones have but two. The first molar in each jaw has the largest and highest crown, while the third has the smallest and the lowest, and, consequently, as a rule, the first lower molar is the largest of the group.

The cusps of the molar teeth are four, rarely five in number, two being lingual and two buccal. In the lower molars the four cusps are separated by a tolerably regular cruciform groove (Fig. 331), and since the lingual cusps are higher than the buccal ones, the lower molars look as though they were composed of two fused premolars. The lower first molar usually has five cusps, three buccal and two lingual. In the upper molars the buccal cusps are higher than the lingual and the separating sulci have the form of a slanting H (Fig. 330), so that the lingual and buccal cusps hold an oblique relation to each other. Irregularities in the number and arrangement of the cusps are common, particularly in the third molar (wisdom tooth, see below), which may have from three to five cusps. As in the case of the premolars, the frontal surfaces of the crowns of the molars are in relation with each other, so that an anterior and a posterior surface of contact may be recognized. Both the lingual and the buccal surfaces of the molar crowns are convex, and both surfaces of the upper molars (at least of the first) have a longitudinal sulcus, while in the lower molars only the buccal surface presents this marking.

The lower molars have two roots, an anterior and a posterior, which are sometimes grooved. They are of moderate length, compressed in the frontal plane, and their apices are usually bent backward. The grooves are an indication that each root is formed by the fusion of two halves, and in rare instances more than two roots may consequently be present.

The upper molars have three conical roots the ends of which are also bent backward. Two are buccal and one is lingual (or palatine, *i. e.*, directed toward the palate, posterior). All three roots are well developed in almost all cases in the first upper molar, while they may be more or less fused in the second. The latter condition is the rule in the third.

The third molars do not make their appearance until from the twentieth to the twenty-fifth year, and have consequently been called the "wisdom teeth" (*dentes serotini*). They are only rudimentary structures in civilized nations, but in ancient skulls and in those of many savage races they are well developed and frequently but slightly smaller than the second molars. The upper wisdom tooth is always much smaller than the lower, and its roots are usually fused together, although the original number is frequently indicated, particularly by the number of the root-canals. There are frequently only three cusps present. The lower wisdom tooth usually has two short roots and the crown seems better developed than that of the upper jaw.

The upper teeth, particularly the front ones, are normally directed slightly outward, those of the lower row slightly inward, so that the somewhat larger superior dental arch overlaps the smaller inferior one throughout its entire circumference. When the dental arches are in apposition (the so-called position of articulation of the teeth) every tooth is opposed to two teeth of the other jaw (Fig. 338), except in the cases of the upper third molars, which are in contact only with the lower third molars; this condition is due to the front teeth of the upper row being considerably wider than those of the lower.

In contrast to the thirty-two *permanent teeth* forming the adult dentition is the deciduous or "milk" dentition of childhood (Figs. 338 to 340), which contains but twenty *deciduous teeth*, namely, eight incisors, four canines, and four molars (Figs. 335 and 336).

FIG. 344.—Skull of a five-year-old child, prepared as in Fig. 341, seen from the side.
FIG. 345.—Upper and lower jaws of a nine-year-old child, prepared as in Fig. 341, seen from the side.
FIG. 346.—The same preparation as Fig. 343, seen from in front.
FIG. 347.—Upper and lower jaws of a twenty-year-old man, prepared as in Fig. 341. All the teeth, except the lower third molars have broken through.

The dental formula for the deciduous teeth is consequently:

$$\begin{array}{cccccccc} M & C & I & \vdots & I & C & M & \\ \hline \frac{2}{2} & \frac{1}{1} & \frac{2}{2} & \vdots & \frac{2}{2} & \frac{1}{1} & \frac{2}{2} & = 20 \end{array}$$

The deciduous incisor and canine teeth, although smaller, correspond to those of the permanent denture not only in number but likewise in peculiarities of shape. They are also found in the same situation as the permanent teeth of the same name, while the deciduous molars appear at the site of the subsequent premolars. They resemble the permanent molars in having several roots, and in being provided with several cusps. The second (posterior) milk-molars are always larger than the first. The upper molars, like those of the permanent dentition,* have three roots, two buccal and one lingual, but these roots present a marked tendency toward fusion. The lower molars have two roots, and the crowns of both the upper and lower teeth have from four to five irregularly situated cusps.

The teeth of the lower jaw erupt normally before those of the upper (Figs. 339 and 349). The lower central incisor makes its appearance usually in the sixth or seventh month and is soon followed by the corresponding tooth in the upper jaw (in the seventh to the eighth month). The lateral incisors usually erupt in the eighth to the twelfth month, and the lower first molars in the twelfth to the sixteenth month, followed several months later by those of the upper jaw. After the first molars come the canines (sixteenth to twentieth month) and finally the second molars (twentieth to thirtieth month).

The milk-teeth are gradually replaced by the permanent dentition, so that during a certain period in childhood teeth of both sets may be seen alongside of each other, and at this stage the jaws consequently contain a large number of teeth in different stages of development (Figs. 342 to 348). The first permanent tooth to erupt is the lower first molar, which makes its appearance from the fifth to the eighth year and is speedily followed by the corresponding tooth in the upper jaw. The deciduous central incisors are not replaced until the sixth to the ninth year, and the lateral from the seventh to the tenth year. The first premolars erupt from the ninth to the thirteenth year, the permanent canines from the ninth to the fourteenth year, and the second (posterior) premolars from the tenth to the fourteenth year, these last being almost immediately followed by the second molars. The third molars frequently do not make their appearance until

* The upper second milk molar almost completely resembles the corresponding permanent tooth, while the upper first molar is subject to great variation in its shape and in the position of its cusps, which are situated upon two ridge-like prominences (a lingual and a buccal).

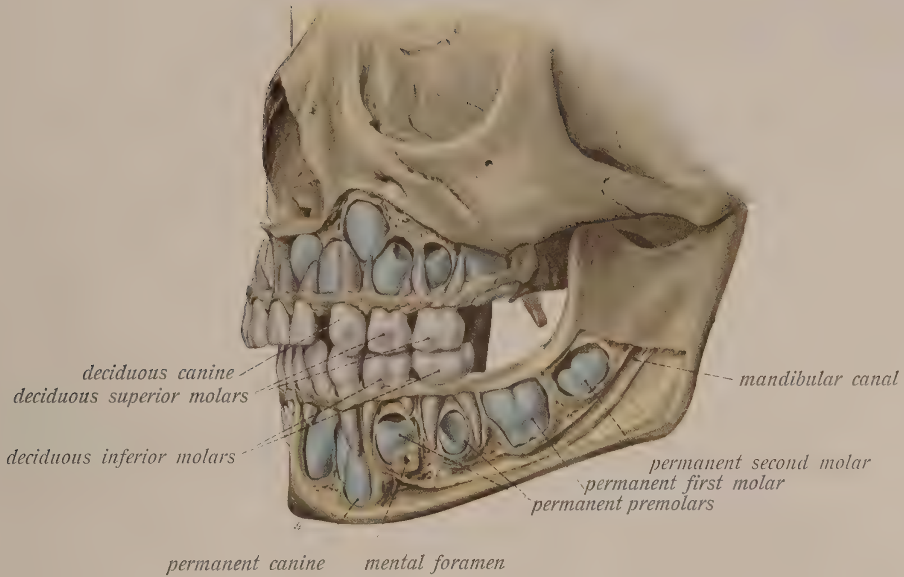

Fig. 344.

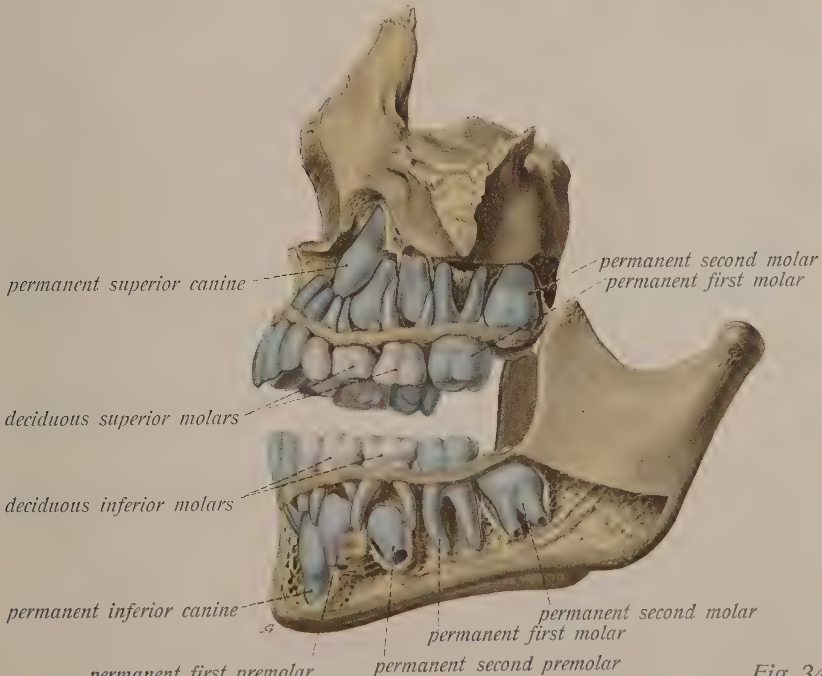

Fig. 345.

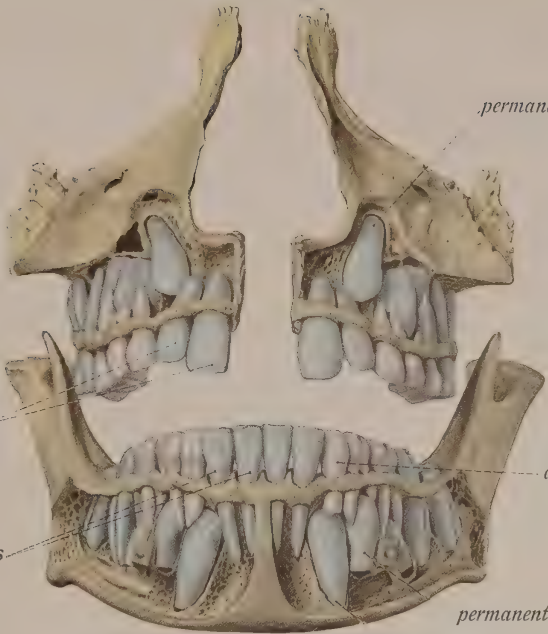

Fig. 346.

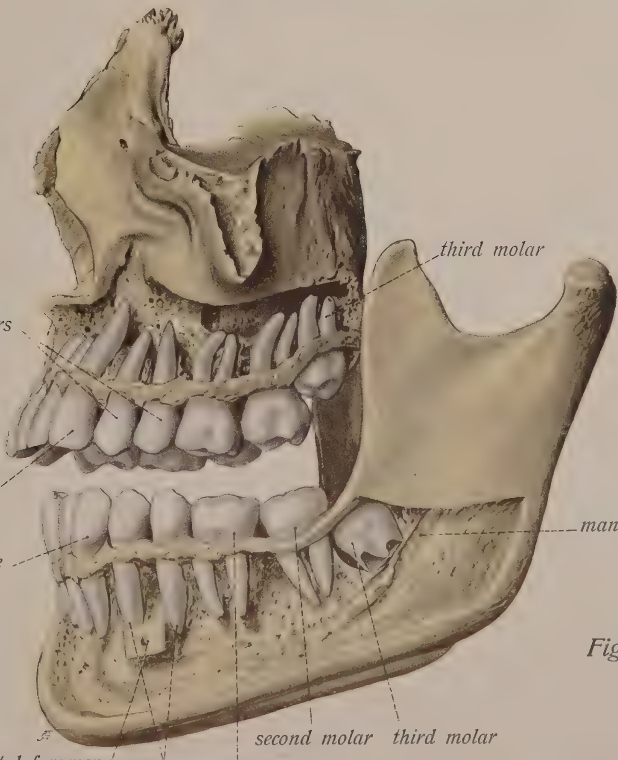

Fig. 347.

quite late (the sixteenth to the fortieth year). The upper premolars usually erupt before the lower, but with this exception the teeth of the lower jaw always appear first.

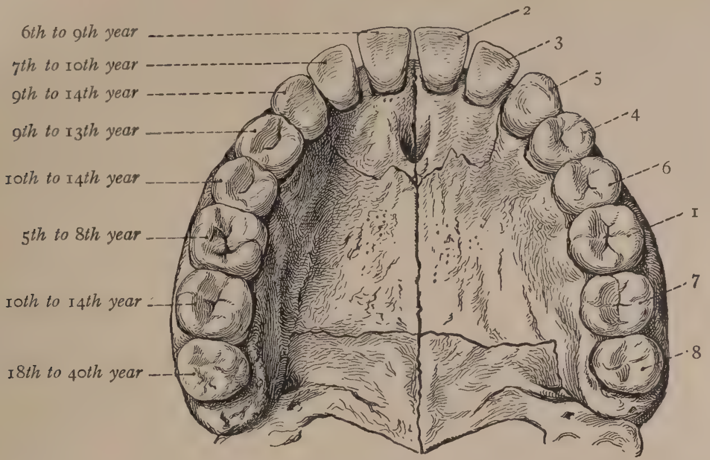

FIG. 348.—Figure showing the time of eruption of the permanent teeth.

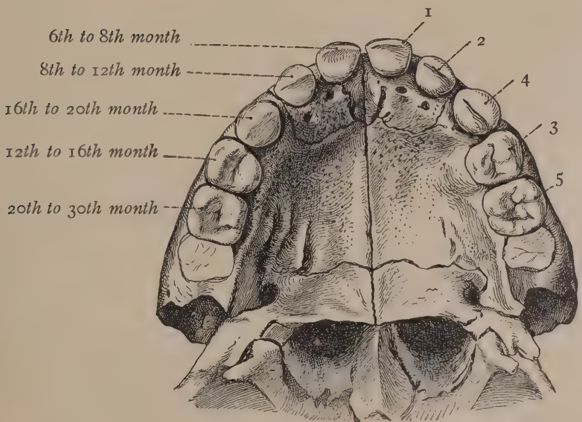

FIG. 349.—Figure showing the time of eruption of the deciduous teeth.

[In these two figures the numbers to the left indicate the time of eruption, those to the right the order of succession.]

The crown of the tooth is formed first and the so-called enamel-organ takes part in its formation only, since it alone possesses enamel. The roots are formed by the dental papillæ and are not complete when the eruption of the tooth occurs and the cement and the circular ligament are formed by the wall of the dental sac. During the development of the tooth the pulp-cavity and particularly the root-canals are relatively large (Fig. 337).

FIG. 350.—View of the sublingual region, the mouth being widely open and the tip of the tongue elevated.

FIG. 351.—View from above of the tongue removed from the body.

FIG. 352.—The superficial layer of the musculature of the tongue seen from the right side.
The mandible has been divided immediately to the right of the median line.

FIG. 353.—The deeper layer of the musculature of the tongue seen from the right side.
The hyoglossus has been cut and the geniohyoideus removed.

The roots of the deciduous teeth are eventually absorbed by the action of osteoclasts, and their crowns either fall out or are broken off mechanically.

Dental anomalies are not common, although supernumerary teeth may be observed and normal teeth may be wanting. The upper lateral incisors are most frequently absent, in which case the central incisors are correspondingly enlarged, and supernumerary teeth most frequently occur in the incisor set. Anomalies of position are common. Very rarely there is observed the beginning of a third dentition.

THE TONGUE (LINGUA).

The *tongue* (Figs. 329 and 350 to 357) is a muscular organ which almost entirely fills the oral cavity. It is covered with mucous membrane and consists of three chief portions: the middle and largest portion, attached to the floor of the mouth, the body; the anterior portion, projecting into the oral cavity, and completely clothed by mucous membrane, the tip; and the posterior portion, attached to the hyoid bone and epiglottis, the root.

In the body of the tongue there may be recognized an inferior attached surface and a convex superior surface or dorsum which is covered throughout its entire length by the oral mucous membrane. The lateral margin of the tongue is rounded; in its anterior part it is free, while posteriorly it is continuous with the soft palate (the glossopalatine arch, see page 24).

When the mouth is closed, the larger anterior portion of the dorsum of the tongue is applied to the palate; its posterior portion borders upon the pharynx at the isthmus of the fauces (see page 42). The junction of the body with the root of the tongue is indicated upon the dorsum by a depression, the *foramen cæcum* (Fig. 351), which leads into a short blind mucous canal, the *lingual duct*, an embryonic rudiment which in the adult exhibits only the orifices of a few mucous glands. From the foramen cæcum the circumvallate papillæ (see below) extend laterally, being arranged like a letter V, the apex of which is directed posteriorly and is formed of the foramen cæcum itself. Parallel and just posterior to the circumvallate papillæ there is frequently a groove, the *sulcus terminalis*, which indicates the dividing-line between the body and the root of the tongue. If this be absent, the row of circumvallate papillæ forms the boundary.

The root of the tongue is connected with the epiglottis by three folds of mucous membrane, a single *median glosso-epiglottic fold* and two *lateral glosso-epiglottic folds*. Between these folds upon either side of the median line there is a roundish pit which is known as the *epiglottic vallecula*.

In the tongue two chief constituents, the mucous membrane and the musculature, mav be recognized. Upon the under surface of the tongue these two constituents are but loosely attached to one another, but upon the dorsum the attachment is firmer, the terminal prolongations of the muscle fibers inserting directly into the *lingual fascia* (Fig. 355), a layer of firm connective tissue situated immediately beneath the mucous membrane.

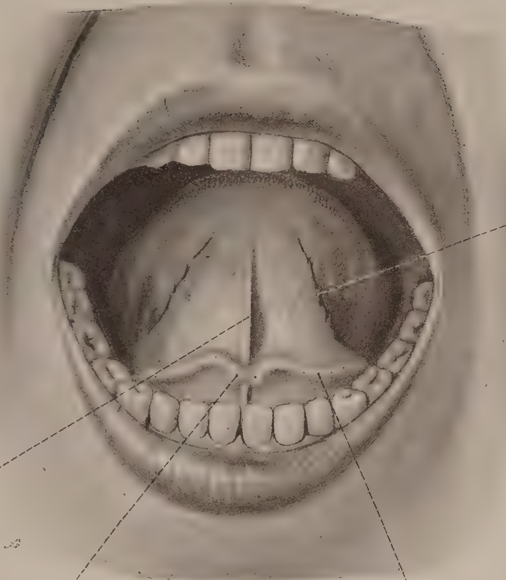

Fig. 350.

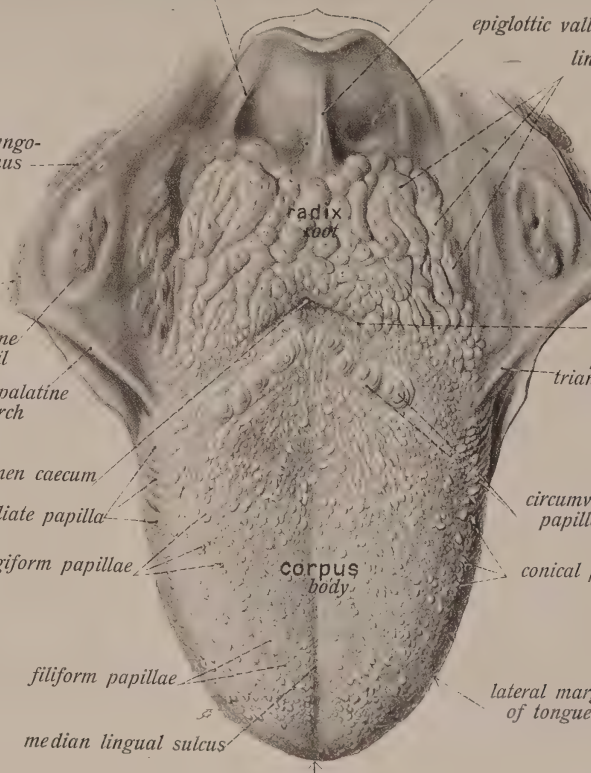

Fig. 351.

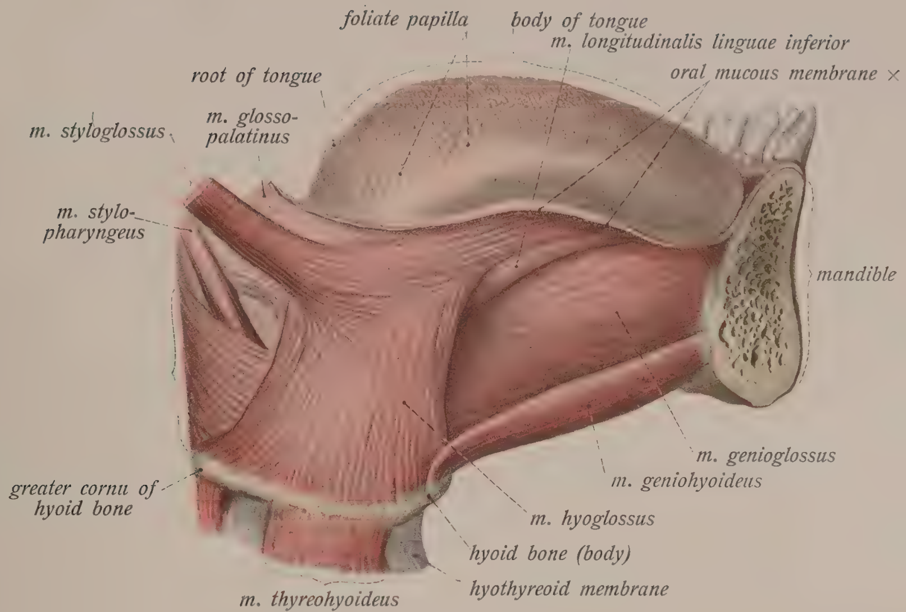

Fig. 352.

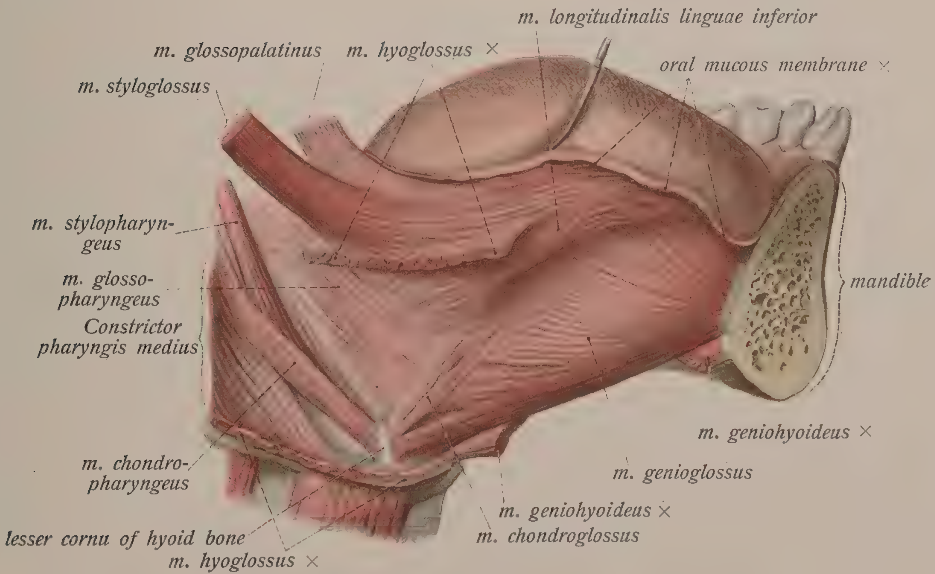

Fig. 353.

Upon the dorsum of the tongue the mucous membrane is sharply divided by the sulcus terminalis or the circumvallate papillæ into a portion covering the body and a portion covering the root of the organ, and the two portions differ from each other in such a way that the anterior one may be termed the papillary portion and the posterior the tonsillar.

The anterior portion owes its characteristic velvety appearance to the lingual papillæ (Fig. 351), which are in general of a conical shape and project above the level of the mucous membrane. According to their shape, the following varieties may be recognized:

1. The *filiform papillæ* have the form of elongated cones rather than of cylinders, and are present in large numbers over the entire papillary portion of the mucous membrane, and especially at the sides and tip of the tongue, where they attain their greatest length. The great majority of the lingual papillæ are of this type.

2. The *conical papillæ* are found scattered among the filiform structures and are not sharply differentiated from them.

3. The *fungiform papillæ* occur scattered among the filiform papillæ at the sides and tip of the tongue and are characterized by having the top broader than the base or pedicle. A subvariety of these constitute:

4. The *lenticular papillæ*, which are lower than the fungiform but otherwise similar to them.

5. The *circumvallate papillæ* (papillæ vallatæ), so named because they are surrounded by a circular wall-like elevation of the mucous membrane. They resemble the fungiform in shape, but are larger, and their surfaces are frequently slightly depressed beneath the general surface. In their more minute structure, however, they differ markedly from the fungiform papillæ.

They are few in number and are always arranged in a typical manner upon the dorsum of the tongue. Their number varies between seven and twelve, and they are arranged in a V-shaped manner, the apex (of the V) being at the foramen cæcum (see page 34). They may be situated at unequal distances from one another and rarely they are arranged in two rows.

6. The *foliate papillæ* are but rudimentary structures in the human subject.* They are arranged in several parallel transverse folds, usually only faintly indicated, upon the lateral margins of the tongue just in front of the glossopalatine arch (see page 24). Unlike the other transverse folds and wrinkles in the relaxed tongue of the dead subject, the folds or laminæ of the foliate papillæ are not obliterated by traction.

(For further details concerning the structure of the lingual papillæ see the Sobotta-Huber "Atlas and Epitome of Normal Histology," Saunders' Medical Hand-Atlases.)

The posterior tonsillar portion of the lingual mucous membrane is markedly different from the anterior papillary portion (Fig. 351). It is characterized by the presence of lymphatic structures, the *lingual follicles*, which together form a diffuse tonsillar structure, the *lingual tonsil*, and it is also particularly rich in mucous glands (see page 40). Each lingual follicle forms a small rounded elevation with a fine central opening; at the root of the tongue they form a dense compact mass, while toward the epiglottis and the adjacent palatine tonsil they are more scattered.

* In many mammals, in the rabbit, for example, the foliate papillæ are well developed and are the chief site of the sense of taste.

FIG. 354.—The musculature of the tongue seen from below.
The genioglossi have been separated from the mandible and the right hyoglossus has been cut.
FIG. 355.—Median longitudinal section of the tongue.
FIG. 356.—Transverse section of the middle portion of the tongue.
FIG. 357.—Transverse section of the tip of the tongue.

The sublingual mucous membrane (Fig. 350) is smooth and thin and exhibits the ordinary characteristics of the oral mucous membrane (see page 27). In the median line, beneath the tip of the tongue, it presents a fold, the *frenulum*, to either side of which is found a *plica fimbriata* (Figs. 350 and 354), which is always well developed in the newborn and less distinct, though rarely entirely absent, in adult life. This fold is always lobulated in the newborn, and usually so in the adult, and gradually disappears as it runs backward and outward from the anterior extremity of the frenulum. In the floor of the mouth just beside the anterior portion of the lateral margin of the tongue, and running obliquely from behind forward and inward, is a fold, the *sublingual fold* (Fig. 350), which is produced by the underlying secretory duct of the submaxillary gland (see page 39) and usually contains the orifices of the lesser sublingual ducts. The two folds converge toward the posterior extremity of the frenulum, in the immediate proximity of which they terminate in a small elevation, the *sublingual caruncle*, which marks the orifice of the submaxillary duct.

THE LINGUAL MUSCLES.

The muscles of the tongue (Figs. 352 to 357) are divided into two groups: (1) Those which take origin from the skeleton (skull and hyoid bone) and insert into the tongue; (2) those muscles which belong solely to the tongue, both the origin and insertion being situated within the organ. The first group is composed of the genioglossus, the hyoglossus (chondroglossus), and the styloglossus.

The *genioglossus* (Figs. 352 to 356) is the strongest of all the lingual muscles and arises by a tendon from the mental spine (superior genial tubercle) of the mandible. It is a paired muscle and is situated just to one side of the median line so that the internal surfaces of the two muscles are in apposition. The majority of the fibers terminate in the lingual mucous membrane, or rather in the lingual fascia, but the most inferior fasciculi pass almost horizontally backward immediately above the geniohyoid and insert into the body of the hyoid bone and into the epiglottis (by means of elastic tendinous fasciculi). The adjacent fibers also at first pass backward from their point of origin, but soon curve sharply upward to insert into the mucous membrane of the dorsum, while the most anterior fibers pass almost vertically upward and then curve slightly forward into the tip of the tongue.

The *hyoglossus* (Figs. 352 to 354) is a flat quadrangular muscle situated at the side of the floor of the mouth, and arises from the body and greater and lesser cornua of the hyoid bone. The portion coming from the lesser cornu, which is known as the *chondroglossus* (Fig. 353), is not always present. The portion of the muscle arising from the body of the hyoid bone is the strongest, that originating from the greater cornu being considerably flatter, and the fasciculi from both origins pass obliquely upward and forward into the tongue, where they pass between the longi-

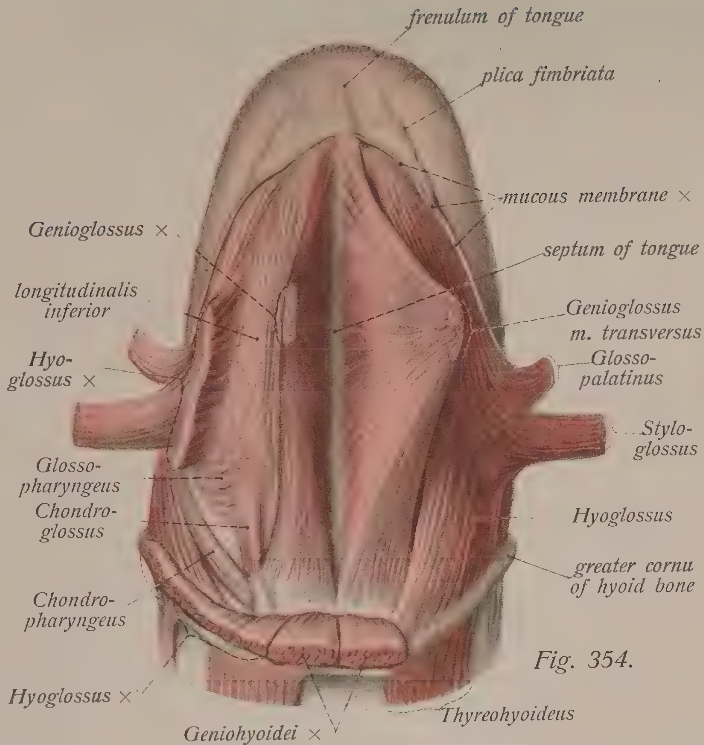

Fig. 354.

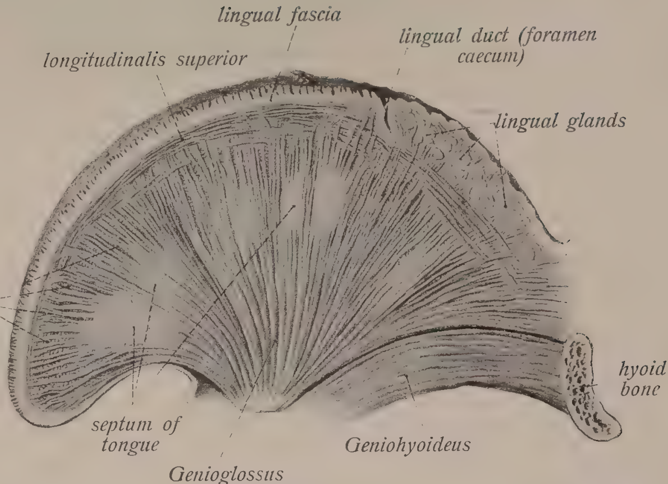

Fig. 355.

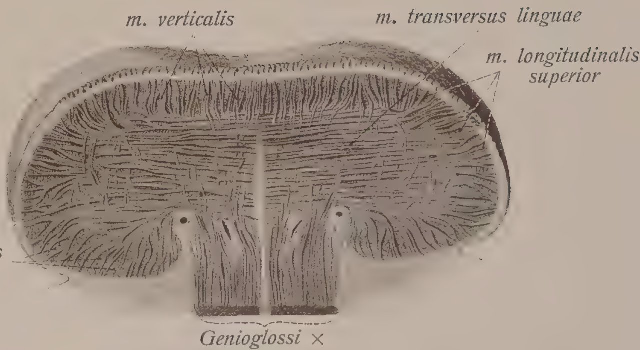

Fig. 356.

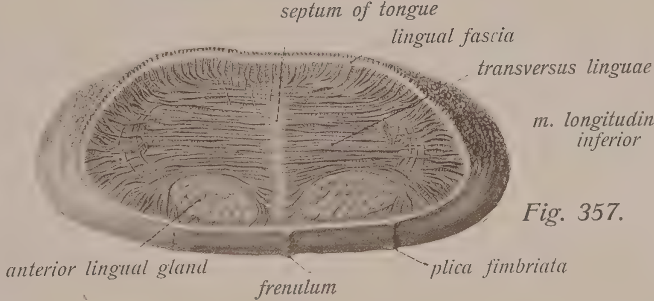

Fig. 357.

tudinalis inferior and the styloglossus, partly interlacing with the latter muscle. The fibers of the chondroglossus, concealed by the remaining portions of the hyoglossus, pass from the lesser cornu to the dorsum of the tongue to mix with the fibers of the longitudinalis superior.

The *styloglossus* (Figs. 352 to 354) is a well-defined muscle which arises from the styloid process of the temporal bone and frequently also from the stylohyoid and stylomandibular ligaments. It becomes markedly flattened as it approaches the tongue and is inserted principally into the lateral margin of that organ as far forward as the tip, lying laterally to the hyoglossus and longitudinalis inferior, some of its fibers also being continuous with the muscular layer designated as the longitudinalis superior (see below). Smaller fasciculi, situated internally and above, penetrate obliquely into the posterior portion of the tongue as far as the median line.

The muscles situated entirely within the tongue are as follows:

1. The *longitudinalis inferior* (Figs. 354 and 356), a flat well-defined muscle upon the lower surface of the tongue, situated between the genioglossus and hyoglossus behind and between the styloglossus and genioglossus in front. Its fibers run in the sagittal plane.

2. The *longitudinalis superior* (Figs. 355 to 357), a layer of sagittal muscular fasciculi placed immediately beneath the mucous membrane of the dorsum of the tongue and largely made up of prolongations from the other lingual muscles (see above). It is consequently not a separate and distinct muscle.

3. The *transversus linguæ* (Figs. 356 and 357), composed of a large number of muscular fasciculi which run almost transversely from the median septum to the surface of the lingual mucous membrane, in such a manner that they are intersected by numerous vertical and sagittal fasciculi, and finally insert between the lamellæ of the radiating fibers of the genioglossus. The fasciculi of the glossopalatinus are intimately connected with the transversus linguæ and some of them originate from it.

4. The *verticalis* (*perpendicularis*) *linguæ* (Fig. 356) includes all the fasciculi which pass vertically through the tongue from the dorsum to the sublingual mucous membrane.

Between the two genioglossi in the median plane there is a connective-tissue partition usually containing fat, the *septum* (Figs. 353 and 356), which fades away as it approaches the dorsum and does not reach the mucous membrane. It gives origin to the fasciculi of the transversus.

The fibers of all the lingual muscles interlace abundantly, especially toward their insertions, which are not actually into the mucous membrane proper but rather into the adherent lingual fascia.

All the lingual muscles are supplied by the hypoglossal nerve. The lingual glands are considered upon page 40.

The development of the tongue is intimately connected with that of the oral cavity. The portions of the tongue situated in front of and behind the sulcus terminalis are formed independently, the anterior portion arising partly from the paired mandibular processes and partly from the so-called tuberculum impar which forms the middle of the anterior portion of the tongue, while the root originates from portions of the second and third visceral arches.

THE GLANDS OF THE ORAL CAVITY (THE SALIVARY GLANDS).

The glands which secrete the saliva (Figs. 359 to 361 and 364) are divided into two groups: the numerous small glands in the walls of the oral cavity and the three large (paired) salivary glands.

FIG. 358.—The parotid gland in position.

FIG. 359.—The submaxillary and sublingual glands.

The mandible has been divided in the median line and the tongue has been removed. * = A flat process of the submaxillary gland which extends above the mylohyoid muscle.

FIG. 360.—The submaxillary gland in position in the submaxillary fossa.

FIG. 361.—The submaxillary and sublingual glands seen from the submaxillary fossa.

The anterior belly of the digastric has been removed, the mylohyoid has been divided and turned aside, and the submaxillary gland is tilted backward.

The latter are the parotid, the submaxillary, and the sublingual. They possess excretory ducts of varying lengths, which empty into the oral cavity.

The *parotid* (Figs. 359, 360, 364, and 365), the largest oral salivary gland,* is of a flattened irregular triangular shape and is situated in front of the external ear in the parotideo-masseteric region and partly also in the retromandibular fossa. Its slightly convex external surface is covered by the skin, the prolongations of the platysma (and risorius), and the parotideo-masseteric fascia, while the slightly concave internal surface rests chiefly upon the masseter.

The anterior portion of the gland is much the thinner, and the anterior somewhat concave margin is slightly beveled and lies upon the external surface of the masseter. The inferior margin is directed somewhat posteriorly, so that it forms an acute angle with the anterior margin, this tip of the gland being situated in the neck and sometimes extending as far down as the submaxillary gland. The inferior and posterior margin rests upon the anterior margin of the sternocleidomastoid and the superior margin is generally irregular and is in relation with the zygoma and the external auditory meatus.

The posterior portion of the gland, situated behind the posterior margin of the masseter, covers the outer surface of the ramus of the lower jaw, and its *retromandibular process* (Fig. 366) extends behind the ramus to come into relation with the internal pterygoid, the posterior belly of the digastric, and the muscles coming from the styloid process. This glandular process usually also reaches as far as the internal carotid artery and the internal jugular vein.

The parotid gland is traversed by the branches of the facial nerve which are situated nearer the internal than the external surface and form the parotid plexus within its substance. The upper branches of the external carotid, particularly the superficial temporal and some of its ramifications, as well as the posterior facial (temporo-maxillary) vein, may also be more or less enveloped by the lobules of the gland.

The duct of the parotid gland, the *parotid duct* (*ductus Stenoni*) (Fig. 358), appears at the upper portion of the anterior margin of the gland and passes almost transversely across the masseter, bends just in front of its anterior margin, and passes through the fatty tissue in this situation (the buccal fat pad) and the buccinator to the buccal mucous membrane which it perforates obliquely. The orifice of the duct is in the vestibulum oris and appears as a rounded slit opposite the upper second molar tooth.

Several small conglomerations of lobules are very frequently observed about the parotid

* Oral salivary gland in contrast to the abdominal salivary gland, the pancreas.

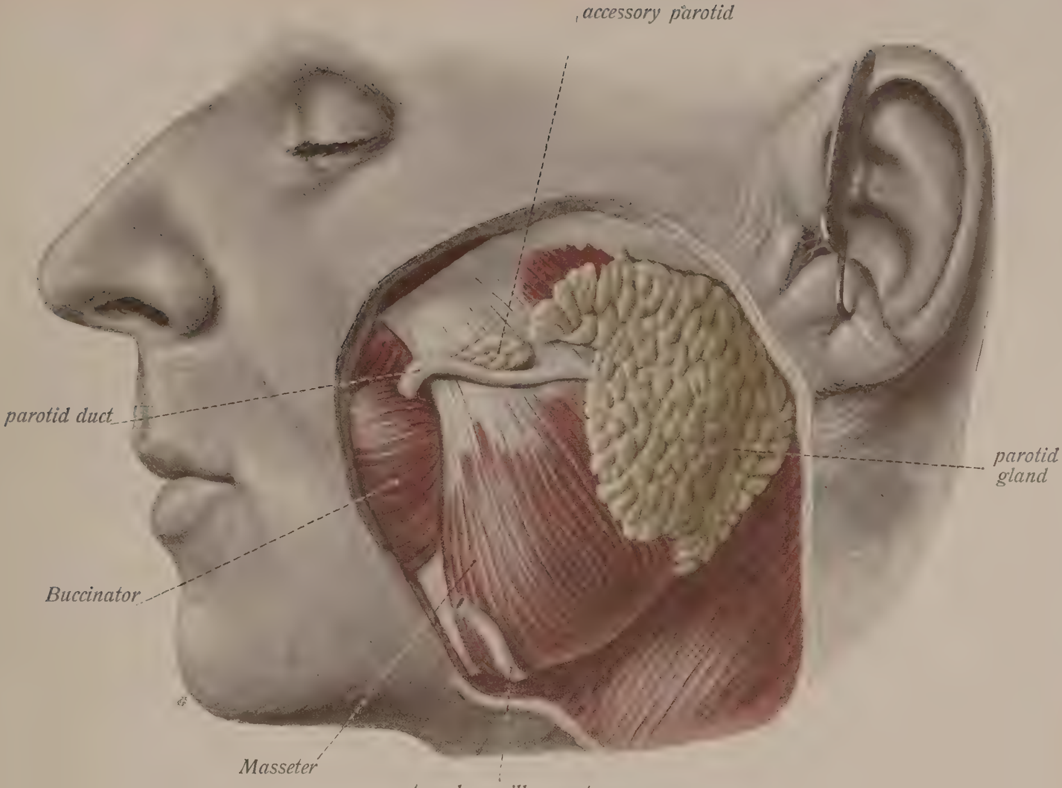

Fig. 358.

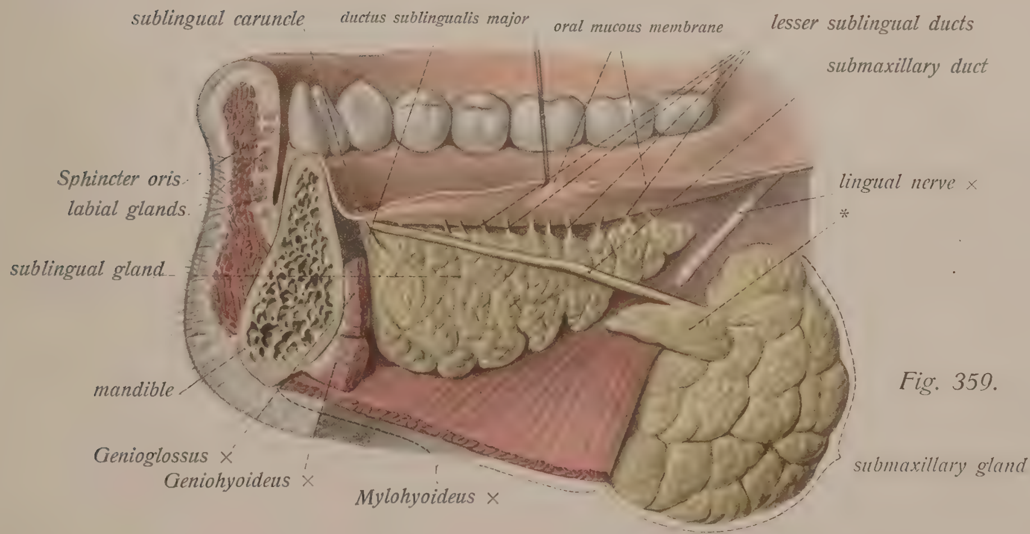

Fig. 359.

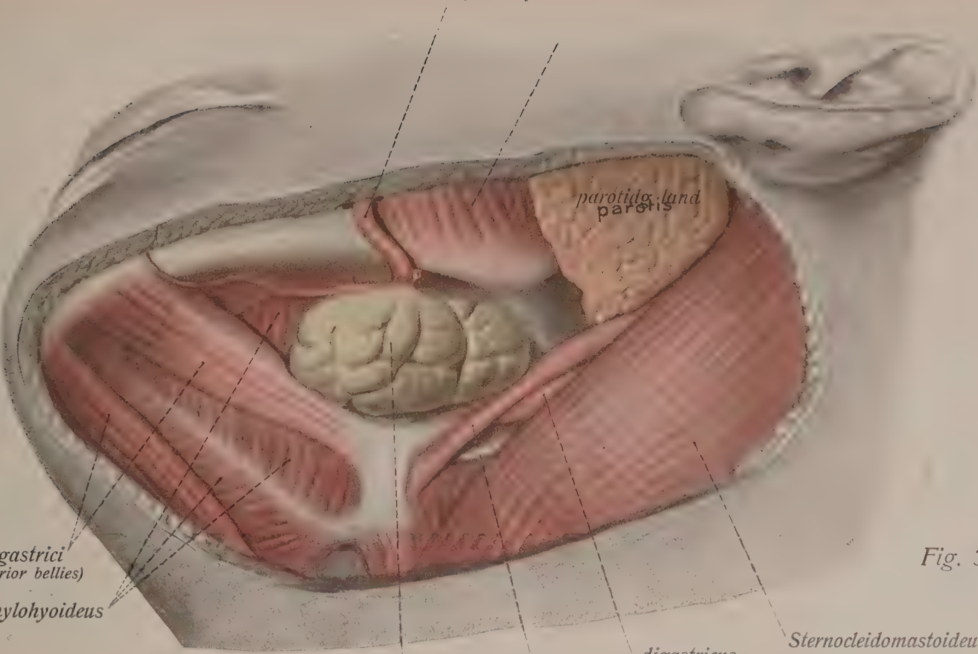

Fig. 360.

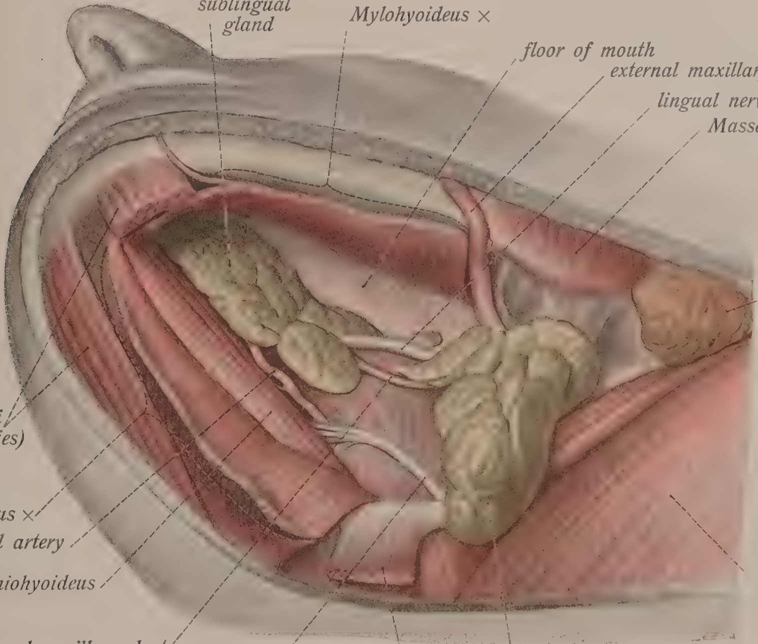

Fig. 361.

duct and are known as the *accessory parotid gland*. The parotid gland is grayish-yellow or yellowish-brown in color and seems distinctly lobulated like the other salivary glands, but the lobules are quite small; at the margins of the gland they are frequently isolated, but throughout the chief mass of the structure they are arranged compactly.

The *submaxillary gland* (Figs. 359 and 360) is a rounded structure, the long axis of which is in the sagittal plane. It is found in the neck, in the submaxillary region, immediately beneath the platysma and the cervical fascia, the latter structure forming a fibrous capsule for the gland.

The greater portion of the submaxillary gland lies beneath the mylohyoid muscle in the space between the angle of the jaw and the two bellies of the digastric (Fig. 360). It also borders upon the stylohyoid and styloglossus, and its internal surface is in relation with the hyoglossus. The external maxillary (facial) artery and its accompanying vein run in the immediate vicinity. The upper margin of the gland rests against the body of the jaw and is lodged in a depression which is not always distinct, the submaxillary depression (see Vol. I, p. 72).

The gland is yellowish-white in color and is distinctly lobulated, the lobules being considerably larger than those of the parotid. A thin and markedly flattened glandular process extends upward between the internal pterygoid and the mylohyoid to the sublingual gland and accompanies the secretory duct for some distance (Fig. 359, *).

The *submaxillary duct* (*ductus Whartoni*) (Fig. 359) is the size of an ordinary quill; it is given off from the upper part of the gland and runs above the mylohyoid, between that muscle and the mucous membrane of the floor of the mouth (or the sublingual gland), passing from behind forward and inward and producing the sublingual fold (see page 36). The orifice in the oral cavity is situated on the sublingual caruncle beside the frenulum beneath the tip of the tongue (Fig. 350).

The *sublingual gland* (Figs. 359 and 361) is an elongated flattened structure with its long axis in the sagittal plane, and may be distinctly seen beneath the mucous membrane of the floor of the mouth when the tip of the tongue is raised. The external border is lodged in a depression in the inferior maxillary bone, the sublingual depression (see Vol. I, p. 72), and the posterior margin is in relation with the submaxillary gland, the internal margin with the genioglossus, and its lower surface rests upon the mylohyoid. In the immediate vicinity of the gland are the sublingual artery and the lingual nerve.

The gland is white or light-gray in color and has distinct lobules which are smaller than those of the submaxillary. It is the smallest of the three salivary glands and is not so compactly arranged, frequently consisting of several glandular masses which are only loosely connected. It does not possess a common duct, but the secretion from the distinctly separated glandular components is poured out through ten or twelve ducts known as the *lesser sublingual ducts* (*ducts of Rivinus*), which empty immediately into the oral cavity by a number of small punctiform orifices in the region of the sublingual fold (Figs. 350 and 359). The anterior portion of the gland, however, frequently gives off a somewhat larger duct, which is known as the *greater sublingual duct* (*duct of Bartholin*), and this either empties independently at the sublingual caruncle beside the submaxillary duct or pours its secretion into the latter structure immediately before its termination. Both the submaxillary and the sublingual glands consequently empty into the oral cavity, while the orifice of the duct of the parotid gland is situated in the vestibulum oris.

[The sublingual glands differ from the submaxillary and parotid in that each is really composed of a number of independent glands which open into the oral cavity, each by its own duct. These glands are known as the *alveolo-lingual glands* and their existence explains the multiplicity of ducts which characterizes the sublingual.—Ed.]

The greater number of the smaller glands of the oral cavity have been previously considered (see pages 22 and 24). They are found generally distributed throughout the walls of the oral cavity and are usually smaller than a pea and of irregular shape. In some situations they are isolated, while in others they are compactly arranged. The following groups may be recognized:

1. The *labial glands* (Fig. 325), in the submucosa of the lips, situated between the mucous membrane and the musculature;

2. The *buccal glands* (Fig. 367), situated between the oral mucous membrane and the buccinator, between the fasciculi of the latter muscle, and even upon its outer surface;

3. The *molar glands* (Fig. 327), small isolated structures in the mucous membrane behind the last molar teeth;

4. The *lingual glands*, of small size, situated beneath the mucous membrane of the dorsum and partly surrounded by muscular tissue. According to their structure they are partly mucous and partly albuminous glands, and they are almost entirely absent from the tip of the organ, more numerous at the lateral margins, and particularly plentiful in the region of the circumvallate papillæ (albuminous glands) and among the lingual follicles. A somewhat larger gland among the smaller ones is the *anterior lingual gland* (gland of Blandin or Nuhn) (Fig. 357), situated in the tip of the tongue, which in reality is a conglomerate of several smaller glands. It is placed between the muscular fibers in the tip of the tongue and empties by several ducts upon or near the plica fimbriata;

5. The *palatine glands* (Fig. 327) are found in the mucous membrane of both the hard and the soft palates and particularly in the uvula, where they frequently lie between the muscle fibers. These glands are present upon both surfaces of the soft palate, but the anterior ones are much larger and more compactly grouped. They extend along the palatine arches to the tonsillar sinus, where they are exceedingly plentiful.

The lips are supplied with blood by the superior and inferior labial arteries; the accompanying veins empty into the facial. The lymphatics of this region drain into the submental lymphatic glands. The upper lip is supplied with sensation chiefly by the infraorbital nerve (second division of the trigeminus), the lower lip by the mental nerve (third division of the trigeminus); the labial muscles, like all those of the face, are supplied by the facial nerve.

The arteries for the cheeks are the branches of the external maxillary (facial), the transverse facial, and the infraorbital and buccal branches of the internal maxillary. The veins empty into the anterior facial vein, and the lymphatics pass to the submaxillary and parotid lymphatic glands. The skin is supplied with sensation by the infraorbital nerve, the mucous membrane by the buccal nerve. The motor nerve is the facial.

The arteries for the teeth in the upper jaw come from the internal maxillary (the superior anterior and posterior alveolar branches of the infraorbital artery); the nerves from the second division of the trigeminus, the anterior superior alveolar branches passing to the incisors, the middle superior alveolar branches to the canines and premolars, and the posterior superior alveolar to the molars. The teeth in the lower jaw are supplied by the inferior alveolar (inferior dental) artery and nerve.

The hard palate receives its blood-supply from the great palatine branch of the descending palatine and its nerves from the anterior palatine. The soft palate is supplied by the lesser palatine arteries and the middle and posterior palatine nerves. The lymphatic vessels of the palate empty into the deep facial lymphatic glands.

The tongue has two proper arteries, the linguals from the external carotids. Their chief and terminal branches, the deep lingual arteries (ranine), pass forward to the tip of the organ to anastomose with each other in the ranine arch. The

accompanying veins which transmit the greater quantity of the return blood empty into the common facial vein. The tongue is supplied by three pairs of nerves; the hypoglossal nerves innervate the muscles, the lingual nerves from the third division of the trigeminus supply sensation (the contained fibers of the chorda tympani also regulating secretion); the glossopharyngeal nerves are distributed only to the circumvallate papillæ and their immediate vicinity and are the special nerves of taste. The lymphatics of the tongue pass to the small lingual lymphatic glands situated in the floor of the mouth.

The arteries supplying the parotid gland are the superficial temporal and the transverse facial; the veins empty into the venæ comites of the above-mentioned arteries or into the external jugular. The lymphatics drain into the parotid lymphatic glands. The secretory stimuli are furnished by branches of the auriculotemporal nerve.

The submaxillary gland receives its blood-supply from the external maxillary (facial) artery and the return blood is poured into the anterior facial vein. The lymphatics pass to the submaxillary lymphatic glands and the secretory nerve is the chorda tympani (running in the lingual nerve).

The sublingual gland is supplied with blood by the branches of the sublingual artery and its veins empty into those of the tongue. The lymphatics run to the submaxillary lymphatic glands, and nerve fibers are furnished by the lingual (chorda tympani).

THE FOREGUT.

The foregut includes the pharynx, the œsophagus, and the stomach.

THE PHARYNX.

The *pharynx* (Figs. 362 to 367) may be regarded as a cylindrical tube, markedly flattened from before backward, and is situated in the vertical axis of the body. The lateral and posterior walls are composed of muscular tissue, but anteriorly it communicates by a large opening with the nasal and oral cavities. Its roof is formed by the base of the skull. Its posterior wall is in relation with the anterior surfaces of the cervical vertebræ and extends downward to the intervertebral disc between the bodies of the sixth and seventh cervical vertebræ, where it passes into the œsophagus; it is separated from the anterior longitudinal ligament and the longi capitis et colli by loose areolar tissue and by the deep (prevertebral) layer of the cervical fascia. Its lateral wall is in relation with the common and internal carotid arteries, the internal jugular vein, and the glossopharyngeal, pneumogastric, spinal accessory, hypoglossal, and sympathetic nerves.

The pharyngeal cavity (Figs. 328, 364, and 365) is flattened from before backward and is composed of three parts which are placed one above the other but are not sharply separated; they are the *nasal portion* (nasopharynx), the *oral portion* (oropharynx), and the *laryngeal portion* (laryngopharynx). The nasal portion (Figs. 362 to 365) communicates with the nasal cavity through the choanæ (see page 87) and is separated from the oral cavity by the soft palate. Its highest portion is known as the *pharyngeal fornix* (Fig. 363) and is situated immediately beneath the base of the skull.

Each lateral wall of this portion presents the pharyngeal orifice of the tuba auditiva (Eustachian tube), which is on a level with the inferior meatus of the nose. It is a slit-like opening, directed obliquely from above downward and from before backward, the anterior and posterior boundaries being respectively designated as the anterior and posterior lip. The posterior lip is the thicker and contains the free extremity of the cartilaginous tube, which causes a projection known as the *torus tubarius* (Fig. 365) (see section on Organs of Special Sense), while the anterior lip is continuous with a fold which gradually disappears upon the posterior surface of the soft palate, the *salpingopalatine fold* (Fig. 362). At the lower margin of the opening of

FIG. 362.—View of the nasal portion of the pharynx seen from behind, the posterior pharyngeal wall being divided in the middle line.

FIG. 363.—View of the nasal portion of the pharynx and the left palatine tonsil, glossopalatine and pharyngopalatine arches.

The skull is divided close to the median line, the uvula cut off at its root and the tongue drawn somewhat forward.

FIG. 364.—View of the pharynx from behind, its posterior wall being divided in the median line. Horizontal incisions have also been made in its upper portion and its posterior and lateral walls reflected.

FIG. 365.—The muscles of the palate and pharynx seen from behind.

The pharynx has been opened along the posterior median line and its walls turned back. The constrictors have been exposed from the inner surface. On the left side the levator veli palatini has been removed.

FIG. 366.—The constrictors of the pharynx seen from behind.

The posterior part of the skull has been removed. * = A bundle of the superior constrictor arising from the base of the skull.

FIG. 367.—The constrictors of the pharynx seen from the side.

The ramus of the mandible and the lateral portions of the skull have been removed; also the stylopharyngeus, the anterior belly of the digastric and the styloglossus. * = A bundle of the superior constrictor arising from the base of the skull.

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the tube there is an inconstant elevation caused by the underlying levator veli palatini, and a rather distinct fold, the *salpingopharyngeal fold* (Figs. 363 and 364), extends from the torus tubarius to the lateral pharyngeal wall, where it gradually disappears, and above and behind the torus tubarius the pharyngeal fornix upon either side forms a narrow blind pocket, the *pharyngeal recess* (cavity of Rosenmüller). Between the two tubal orifices and actually in the roof of the pharynx is situated the *pharyngeal tonsil* (Fig. 363), a lymphatic structure which is usually distinct only in children.*

The oral portion of the pharynx communicates with the oral cavity through the isthmus of the fauces, the boundary being marked by the pharyngopalatine arches (see page 24). It is the narrowest portion of the pharynx and presents no special structures, except a fold of mucous membrane, the *pharyngo-epiglottic fold*, which passes from the lateral margin of the epiglottis to the outer pharyngeal wall and separates the oropharynx from the laryngopharynx.

The laryngeal portion of the pharynx (Figs. 364 and 365) is the only portion which has an extensive anterior wall. It lies behind the larynx, the posterior wall of which is distinctly visible through the thin pharyngeal mucous membrane, so that there may be recognized a median elevation produced by the plate of the cricoid cartilage (and the arytenoid cartilages) and two deep lateral depressions which correspond to those between the cricoid and arytenoid cartilages internally, and the posterior surface of the thyreoid cartilage externally. These lateral depressions are termed the *piriform recesses* and present a fold of mucous membrane, the fold for the laryngeal nerve (Fig. 364), which passes obliquely from above downward and from without inward, and contains the superior laryngeal nerve. In the laryngopharynx is also situated the entrance to the larynx or *aditus laryngis* (see page 97).

The pharyngeal wall consists of a mucous membrane, of a submucous layer, and of a mus-

* The typical pharyngeal tonsil of the child consists of a number of ridges separated by sulci which converge toward a depression, the *bursa pharyngea* (Fig. 363). This depression subsequently disappears.

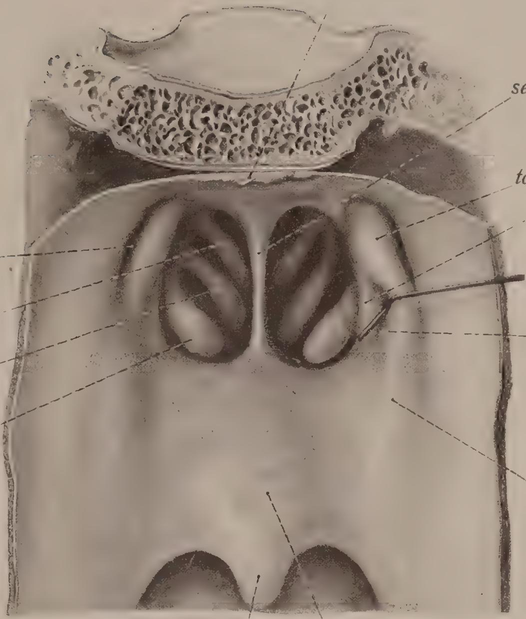

Fig. 362.

Fig. 363.

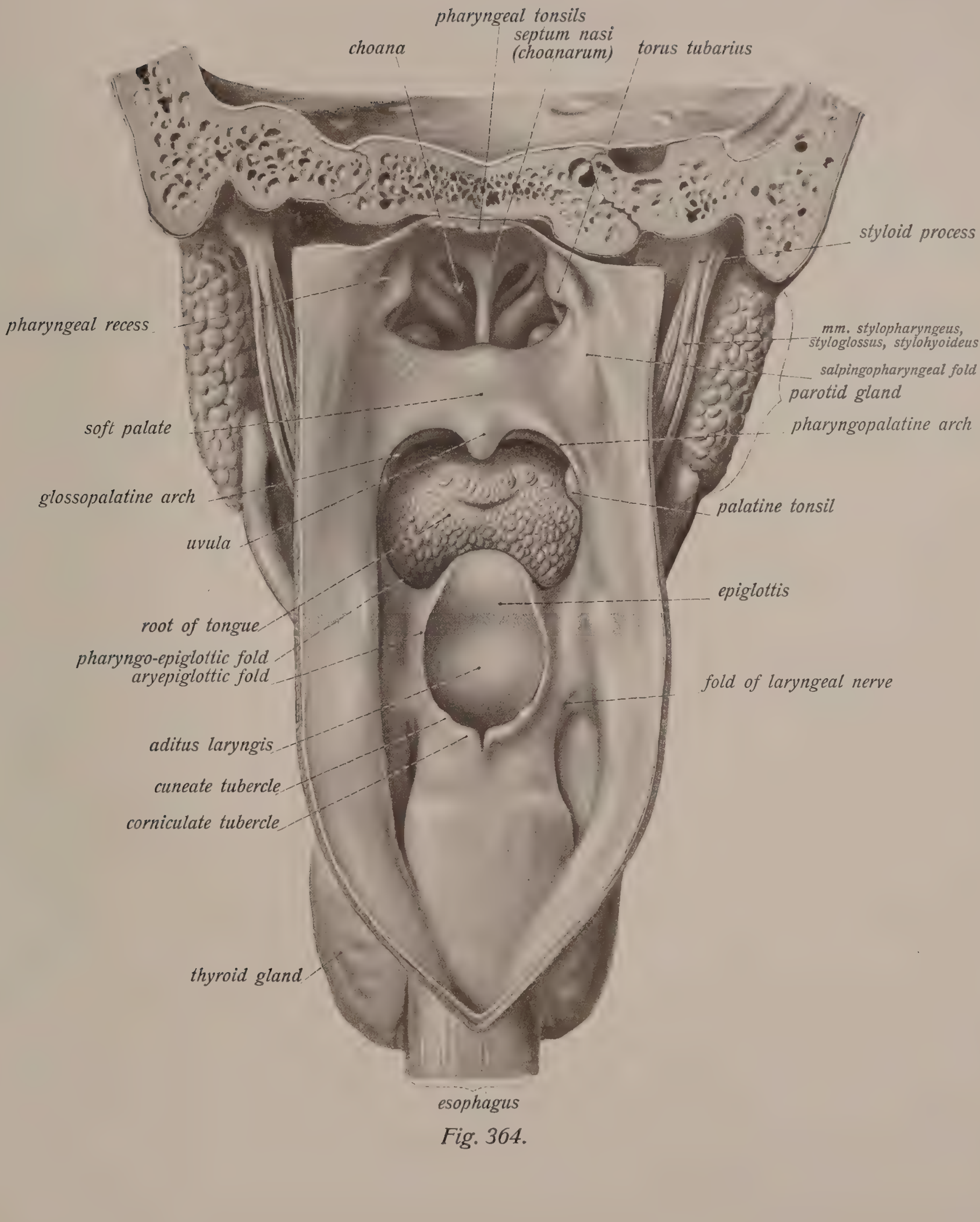
pharyngeal tonsils
choana
septum nasi
(choanarum)
torus tubarius
styloid process
pharyngeal recess
mm. stylopharyngeus,
styloglossus, stylohyoideus
salpingopharyngeal fold
parotid gland
soft palate
pharyngopalatine arch
glossopalatine arch
palatine tonsil
uvula
epiglottis
root of tongue
pharyngo-epiglottic fold
aryepiglottic fold
fold of laryngeal nerve
aditus laryngis
cuneate tubercle
corniculate tubercle
thyroid gland
esophagus

Fig. 364.

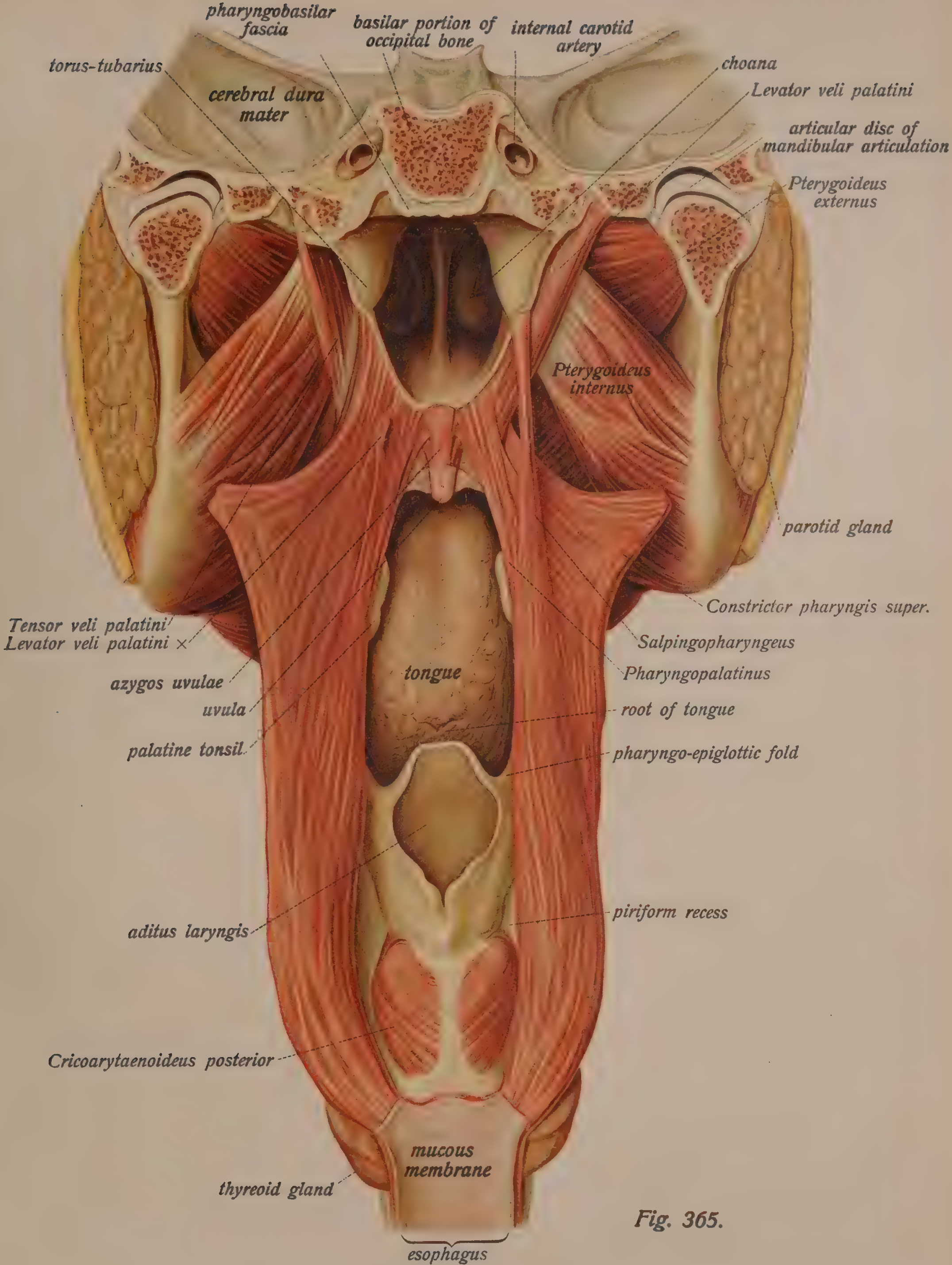
pharyngobasilar fascia
basilar portion of occipital bone
internal carotid artery
torus-tubarius
choana
cerebral dura mater
Levator veli palatini
articular disc of mandibular articulation
Pterygoideus externus
Pterygoideus internus
parotid gland
Constrictor pharyngis super.
Tensor veli palatini
Levator veli palatini ×
Salpingopharyngeus
azygos uvulae
tongue
Pharyngopalatinus
uvula
root of tongue
palatine tonsil
pharyngo-epiglottic fold
piriform recess
aditus laryngis
Cricoarytaenoideus posterior
mucous membrane
thyreoid gland
esophagus

Fig. 365.

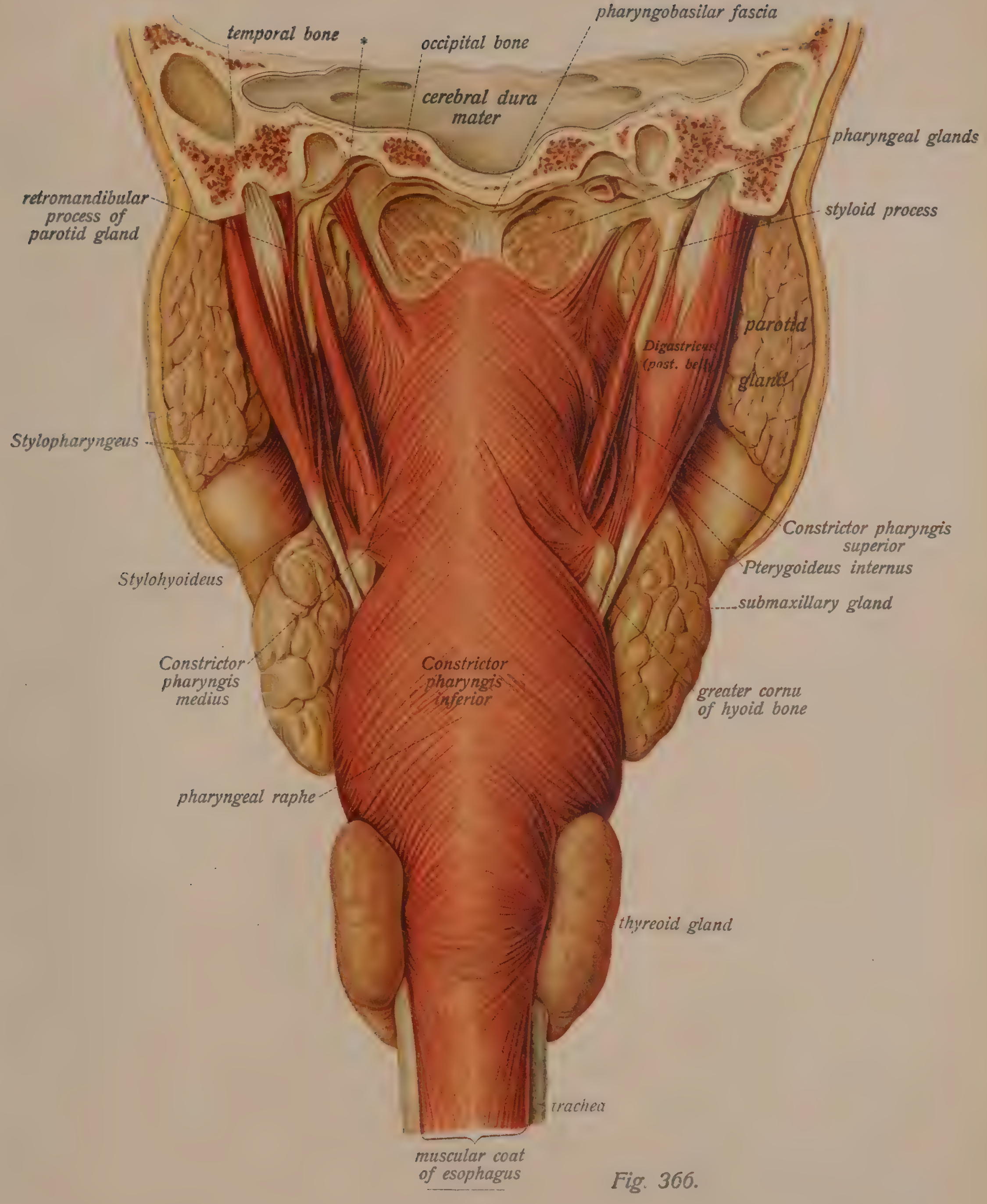
temporal bone
occipital bone
pharyngobasilar fascia
cerebral dura mater
pharyngeal glands
retromandibular process of parotid gland
styloid process
parotid gland
Digastricus (post. belly)
Stylopharyngeus
Constrictor pharyngis superior
Pterygoideus internus
Stylohyoideus
submaxillary gland
Constrictor pharyngis medius
Constrictor pharyngis inferior
greater cornu of hyoid bone
pharyngeal raphe
thyreoid gland
trachea
muscular coat of esophagus

Fig. 366.

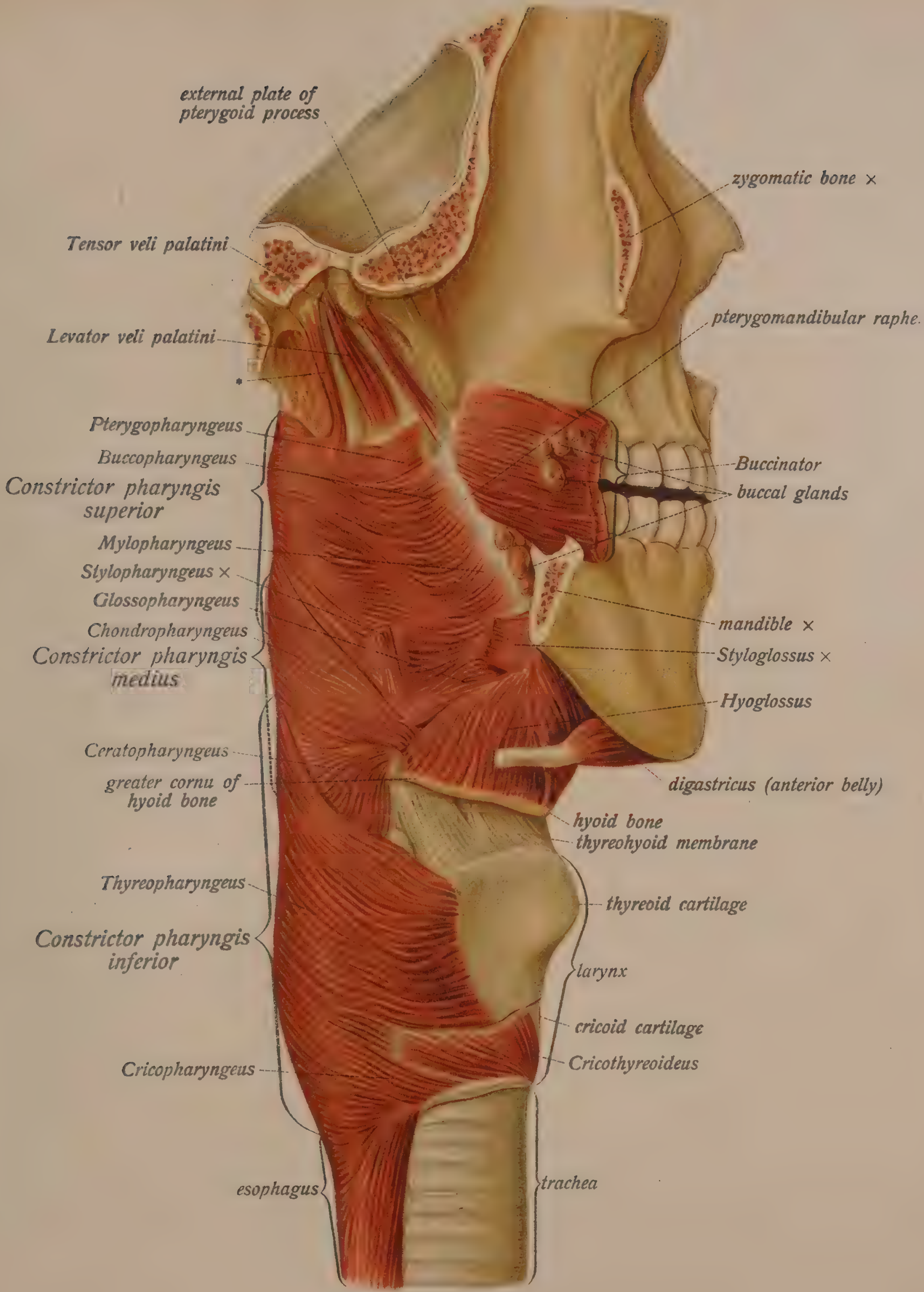
external plate of pterygoid process
zygomatic bone ×
Tensor veli palatini
pterygomandibular raphe.
Levator veli palatini
*
Pterygopharyngeus
Buccopharyngeus
Buccinator
buccal glands
Constrictor pharyngis superior
Mylopharyngeus
Stylopharyngeus ×
Glossopharyngeus
mandible ×
Chondropharyngeus
Styloglossus ×
Constrictor pharyngis medius
Hyoglossus
Ceratopharyngeus
digastricus (anterior belly)
greater cornu of hyoid bone
hyoid bone
thyreohyoid membrane
Thyreopharyngeus
thyreoid cartilage
Constrictor pharyngis inferior
larynx
cricoid cartilage
Cricothyreoideus
Cricopharyngeus
esophagus
trachea

Fig. 367.

cular coat. The mucous membrane is red and smooth, rather thin in its inferior portion, and contains small mucous *pharyngeal glands* (Fig. 366), especially abundant in the upper portion.

In this upper portion the musculature is absent for a distance of about two centimeters, and the submucosa in this situation forms a strong fibrous membrane which is designated as the *pharyngobasilar fascia* (*pharyngeal aponeurosis*) (Figs. 363 and 365) and inserts into the base of the skull.

The muscular coat of the pharynx (Figs. 365 and 366) is found in the lateral and posterior walls with the exception of the uppermost portion. It consists practically of circular fibers which meet in the median line, the *pharyngeal raphe* (Fig. 366), and partly interlace, and in it there may be recognized three flat, thin muscles situated one above the other and known as the constrictors of the pharynx.

The *constrictor pharyngis superior* (*cephalopharyngeus*) (Figs. 366 and 367) is composed of four portions, named according to their origins, which unite to form a single muscular lamina in the lateral wall of the pharynx. The uppermost fasciculi coming from the hamular process and the contiguous portion of the internal plate of the pterygoid process are designated as the *pterygopharyngeus;* the next fasciculi are those of the *buccopharyngeus* and represent the backward continuation of the buccinator, from which they are separated by the pterygomandibular raphe (Fig. 327); the *mylopharyngeus* comes from the posterior part of the mylohyoid line of the mandible; and the small *glossopharyngeus* (Fig. 353), the most inferior portion, originates in the lingual musculature, chiefly from the fasciculi of the transversus linguæ (see page 37).

The *constrictor pharyngeus medius* (*hyopharyngeus*) (Figs. 366 and 367) arises from the lesser (*chondropharyngeus*) and the greater (*ceratopharyngeus*) cornua of the hyoid bone. Only the middle fasciculi pass horizontally to meet in the median raphe, both the upper and the lower fasciculi running obliquely (upward or downward as the case may be) and consequently meeting in the raphe at an acute angle. As a result of this insertion the upper apex of the muscle covers the constrictor pharyngis superior, while the greater portion of the muscle is itself covered by the constrictor pharyngis inferior.

The *constrictor pharyngis inferior* (*laryngopharyngeus*) (Figs. 366 and 367) is the largest and much the longest of the pharyngeal constrictors. It consists of two portions which are separated only at their origins. The larger superior portion, known as the *thyreopharyngeus* (Fig. 367), arises from the entire outer surface of the plate of the thyreoid cartilage, extending from the superior to the inferior cornu; the smaller inferior portion, termed the *cricopharyngeus* (Fig. 367), comes from the outer surface of the ring of the cricoid cartilage. The fibers of this latter portion run almost horizontally; the fibers of the upper portion, on the contrary, pass obliquely upward (the uppermost ones rather sharply) and form an acute angle, the apex of which is directed upward and conceals the greater portion of the constrictor medius.

The *stylopharyngeus* (Fig. 366) acts as an elevator of the pharynx. It arises from the inner side of the styloid process of the temporal bone at the side of and behind the pharynx, and forms a slender, slightly flattened muscle which broadens as it approaches its insertion. The majority of the fibers pass into the lateral wall of the pharynx between the superior and inferior constrictors, with which they interlace, especially with the latter. A few fasciculi also pass to the lateral margin of the epiglottis and to the upper margin of the thyreoid cartilage.

FIG. 368.—Upper portion of the œsophagus, with the aorta and its branches and the trachea and its divisions seen from the right side.

FIG. 369.—Lower portion of the œsophagus and the stomach, with the aorta and a part of the diaphragm. The diaphragm and the pylorus of the stomach are drawn upward and the stomach is rather strongly contracted.

The *salpingopharyngeus* (Fig. 365) is an inconstant muscle situated in the fold of the same name, which arises from the cartilaginous end of the tuba auditiva (Eustachian tube) and passes to the lateral wall of the pharynx.

The pharyngeal muscles are innervated through the pharyngeal plexus (see Neurology).

THE ŒSOPHAGUS.

The *œsophagus* (Figs. 368 and 369) is a muscular tube about 25 centimeters in length which is immediately continuous with the lower portion of the pharynx above and with the cardiac portion of the stomach below. It consists of three portions—the cervical, the thoracic, and the abdominal. The thoracic portion is by far the longest, while the abdominal is very short.

The cervical portion (Fig. 368) is continuous with the pharynx at the level of the sixth cervical vertebra or at the disc between the sixth and seventh vertebræ, this point likewise marking the boundary between the trachea and the larynx. As the pharynx is exactly behind the larynx, so the œsophagus is at first directly posterior to the trachea and immediately in front of the cervical vertebræ and the long cervical muscles, being separated from the latter by the deep layer of the cervical fascia (prevertebral fascia) and by loose connective tissue.

It has in general an almost vertical direction, but even at the beginning it shows a slight tendency to deviate toward the left, so that the lower part of the cervical portion projects to the left somewhat beyond the trachea. This deviation is slight in the cervical region but becomes greater in the thoracic portion of the organ, which extends from the superior thoracic aperture to the œsophageal opening in the diaphragm, and is situated in the posterior mediastinum (see page 110). Unlike the cervical portion, the thoracic œsophagus is not placed immediately in front of the vertebræ, but is separated in its lower portion from these structures by the aorta. It maintains throughout the thorax its general vertical direction, following, however, the curvature of the thoracic vertebræ in its upper portion. The beginning of it is near the anterior surface of the vertebral column and approximately in the median line, and at the tracheal bifurcation the greater portion of the viscus is behind the left bronchus, while below this point it is in contact with the posterior wall of the pericardium (Fig. 460). In the latter situation it is still near the middle line, and for a short distance pursues a course almost parallel with the descending aorta which is situated to the left, but in its further course the œsophagus passes to the left and in front of the aorta, the latter structure displacing it more and more from the median line and from the anterior surface of the vertebral column. In this manner the œsophagus crosses the aorta at an acute angle (Fig. 369) and takes a position in front of the latter and markedly to the left of the median line.

The upper portion of the thoracic œsophagus is in relation upon the right with the vena azygos and posteriorly with the thoracic duct. The pneumogastric nerves also lie immediately upon the œsophagus (see Neurology).

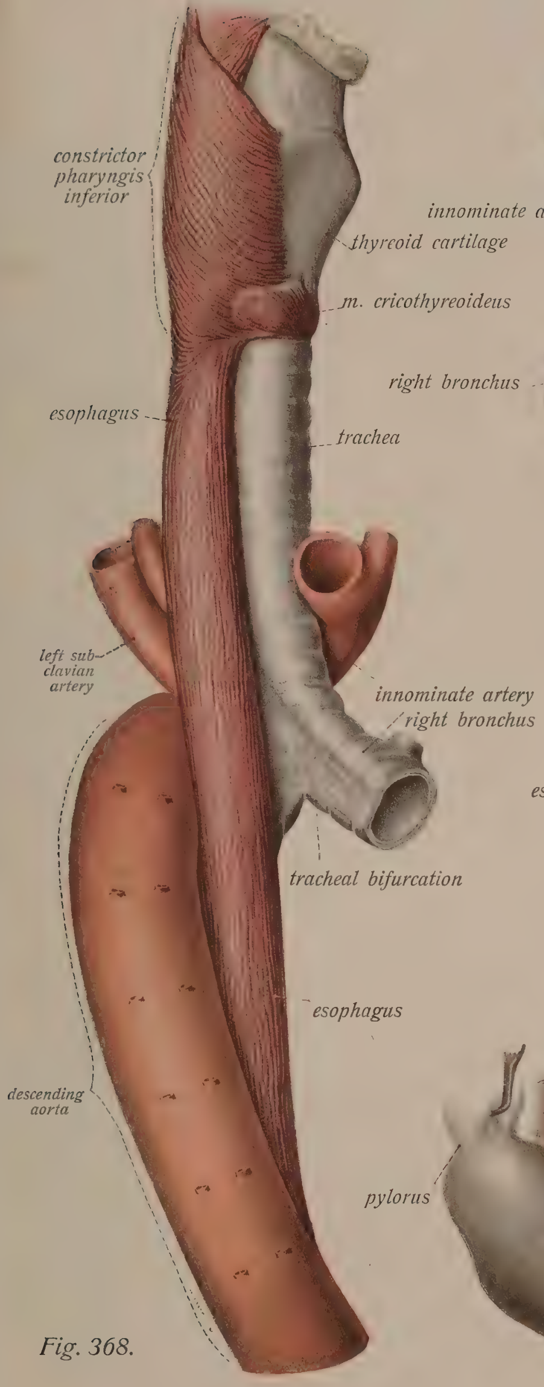

Fig. 368.

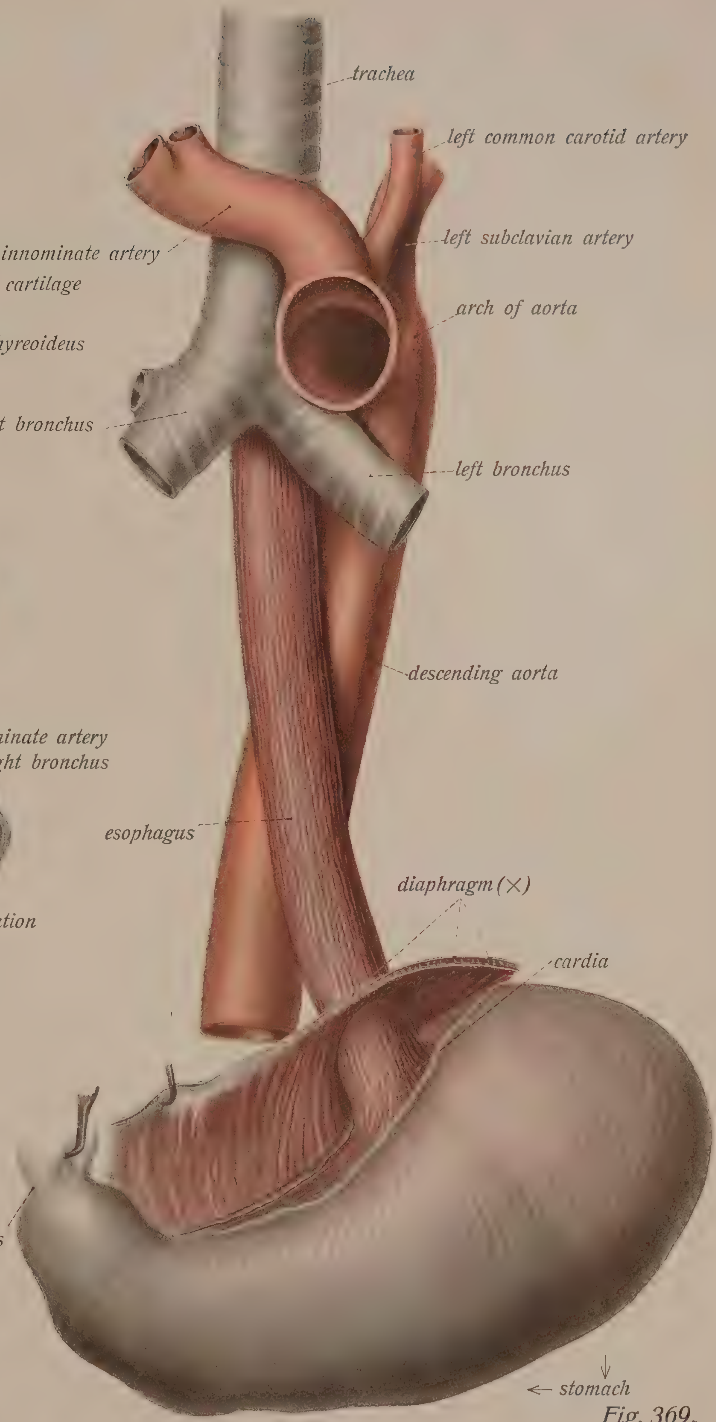

Fig. 369.

The œsophagus enters the œsophageal opening in the diaphragm at the level of the ninth thoracic vertebra, the length of the opening corresponding to the width of a vertebral body. At its passage through the diaphragm it has already taken up its position well to the left of the median line, which is practically occupied by the aorta.

The abdominal portion of the œsophagus is about 1 centimeter long. It passes from the diaphragm rather suddenly to the left (Fig. 369) and empties into the stomach at the level of the eleventh thoracic vertebra.

The œsophagus is not of uniform caliber throughout, but exhibits a variable number of constrictions with intervening fusiform dilatations. It is especially narrow at its commencement, at its passage through the diaphragm and frequently where it crosses the left bronchus. Its wall gradually diminishes in thickness from above downward owing to the replacement of the striated by the nonstriated musculature, and in the empty state of the organ the mucous membrane is arranged in marked longitudinal folds and the lumen is quite small. In the dead subject both the œsophagus and its lumen are usually markedly flattened from before backward. The distinct submucosa contains small mucous œsophageal glands, and the muscular tunic is composed of an inner layer of circular and of an outer layer of longitudinal fibers, the fasciculi of the longitudinal fibers appearing as fine longitudinal stripes upon the outer surface of the viscus. In its course through the posterior mediastinum (see page 110) the musculature is reinforced by fasciculi which originate from the mediastinal pleura (*m. pleuroœsophageus*) and from the wall of the left bronchus (*m. bronchoœsophageus*).

(For further details concerning the histology of the œsophagus the reader is referred to the Sobotta-Huber "Atlas and Epitome of Normal Histology.")

THE STOMACH (VENTRICULUS).

The *stomach* (Figs. 369, 370, 372, 373, 375, 405, 406, 416, and 417) is a sac-like dilatation of the digestive tube intervening between the œsophagus and the intestine. Its general shape is piriform (Fig. 370), being broad and thick toward the left and narrow and thin toward the right, and its upper margin, known as the *lesser curvature*, is short and concave, while its lower one, the *greater curvature*, is long and convex. To the curvatures the peritoneum is attached, and blood-vessels pass along them. The region at which the œsophagus enters is known as the *cardia* and is situated on the upper border of the stomach at the left end of the lesser curvature, and the junction with the intestine, known as the *pylorus*, occurs at the right extremity of the stomach.

There may be recognized an anterior and a posterior wall, both of which are convex and separated from each other by the curvatures, and three chief gastric subdivisions: the cul-de-sac to the left of the cardia, the *fundus;* the *body;* and the *pyloric portion.*

The portion of the stomach adjacent to the pylorus is frequently separated from the body of the viscus by a slight constriction, and its cavity is known as the *pyloric antrum* (Fig. 375). The pylorus itself appears upon the external surface of the stomach as a slight circular constriction (Fig. 370), but upon the internal surface (Fig. 375) it takes the form of a circular fold of no great height which is known as the *pyloric valve.* In the pyloric region the lesser curvature becomes convex and the greater concave, since the stomach curves upward in this situation.

The greater portion of the stomach is situated in the left half of the body; the pyloric portion

FIG. 370.—The stomach, moderately distended, seen from in front.

FIG. 371.—The layers forming the wall of the superior portion of the duodenum, seen from the exterior.

FIG. 372.—The superficial musculature of the stomach, seen from in front and somewhat from above, after removal of the peritoneum.

FIG. 373.—The deeper layers of the stomach musculature, seen from in front. The longitudinal musculature has been completely removed, as has also the upper portion of the circular musculature.

FIG. 374.—Portion of the mucous membrane of the stomach, magnified four diameters.

FIG. 375.—The stomach and duodenum opened from in front. Bristles have been inserted into the openings of the bile and pancreatic ducts.

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only passing to the right of the median line, so that but about one-sixth of the entire organ lies within the right half of the body. The main portion of the stomach is in the left hypochondriac region, the pylorus is in the epigastric region, although in the distended state the viscus also occupies more or less of the mesogastric region. The fundus is the highest portion of the stomach, being situated above the cardia, which in turn is higher than the pylorus, and the lowest portion of the viscus is the most curved portion of the greater curvature; consequently the longitudinal axis of the stomach passes obliquely from above downward and from left to right.

The fundus is in relation with the left leaflet of the diaphragm, with the spleen, and with the left lobe of the liver, the latter structure covering the cardia, the lesser curvature, and part of the pylorus (Fig. 407). The pylorus is in contact with the quadrate lobe of the liver and the gall-bladder, and is continuous with the duodenum. The great omentum is attached to the greater curvature (Fig. 407) (see under Peritoneum, page 75), which is also in relation with the transverse colon, while behind lies the pancreas, separated from the stomach by the bursa omentalis, as well as the left kidney and the left suprarenal body.

With reference to the skeleton the stomach is situated at the level of from (the tenth or) the eleventh to the twelfth thoracic vertebra. The cardia is in front of the tenth or eleventh thoracic vertebra and behind the insertion of the seventh costal cartilage into the sternum. The pylorus is at the right border of the twelfth thoracic vertebra.

The size of the stomach varies greatly according to its degree of distention or contraction; a completely emptied and contracted stomach, relatively infrequent in the cadaver, looks very small and simulates intestine, while the greater curvature of a markedly distended viscus may extend downward to the navel. During marked distention the stomach also undergoes a rotation upon its longitudinal axis so that the greater curvature assumes a more anterior position. The average length of the stomach is 25 to 30 centimeters, its average width 12 to 14 centimeters, and the average thickness of its wall (which likewise varies greatly with the degree of distention) 2 or 3 millimeters.

The serous peritoneal covering of the anterior wall is furnished by the greater peritoneal cavity, while that of the posterior wall comes from the bursa omentalis (see under Peritoneum, page 82). The other constituents of the gastric wall are the muscular coat, the submucous coat, and the mucous coat. The latter differs in structure in the pyloric portion from the mucosa in other parts of the stomach.

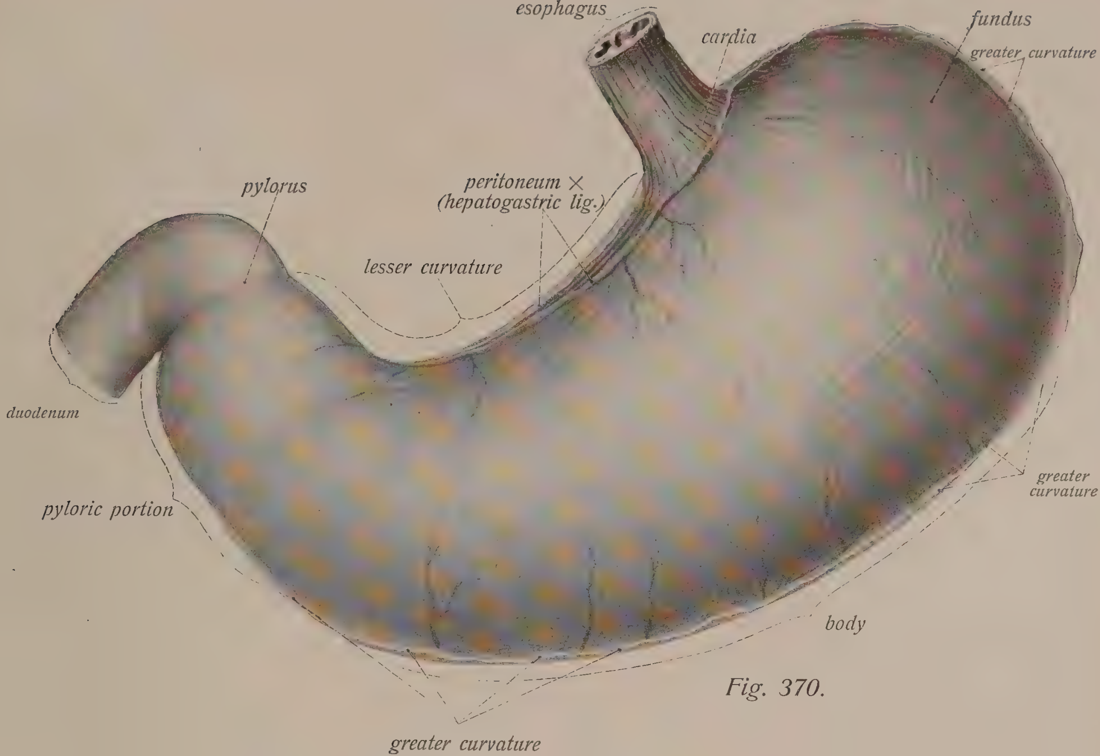

Fig. 370.

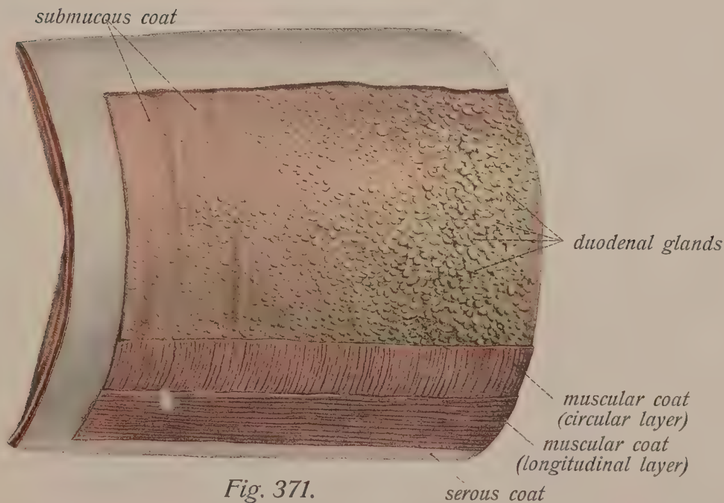

Fig. 371.

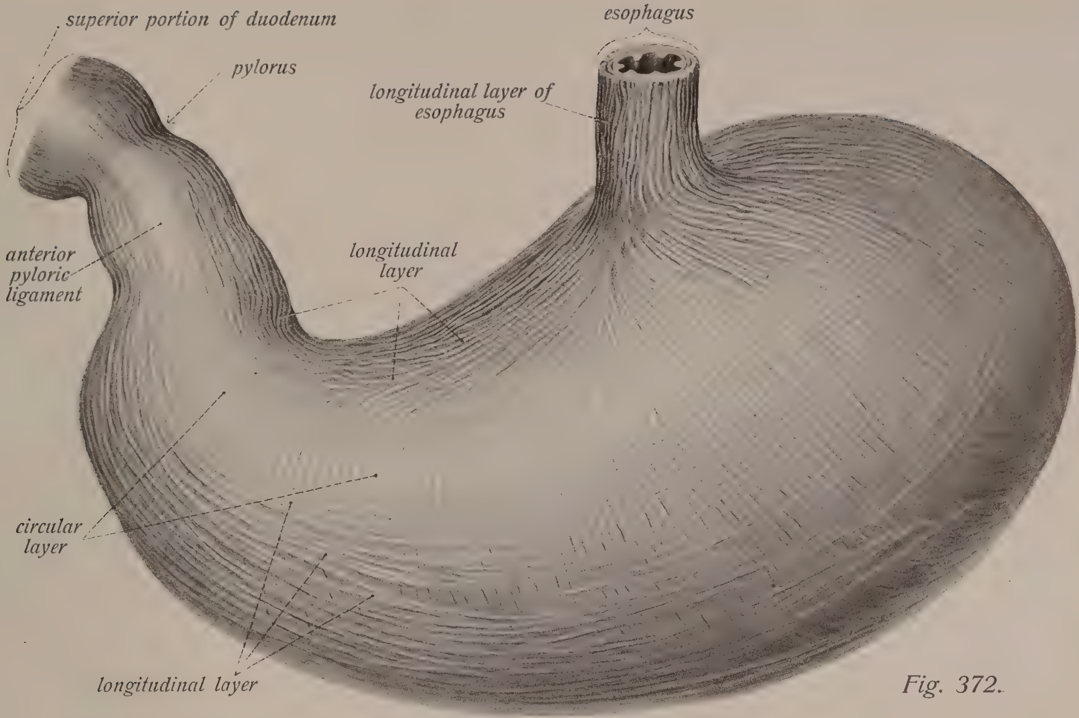

Fig. 372.

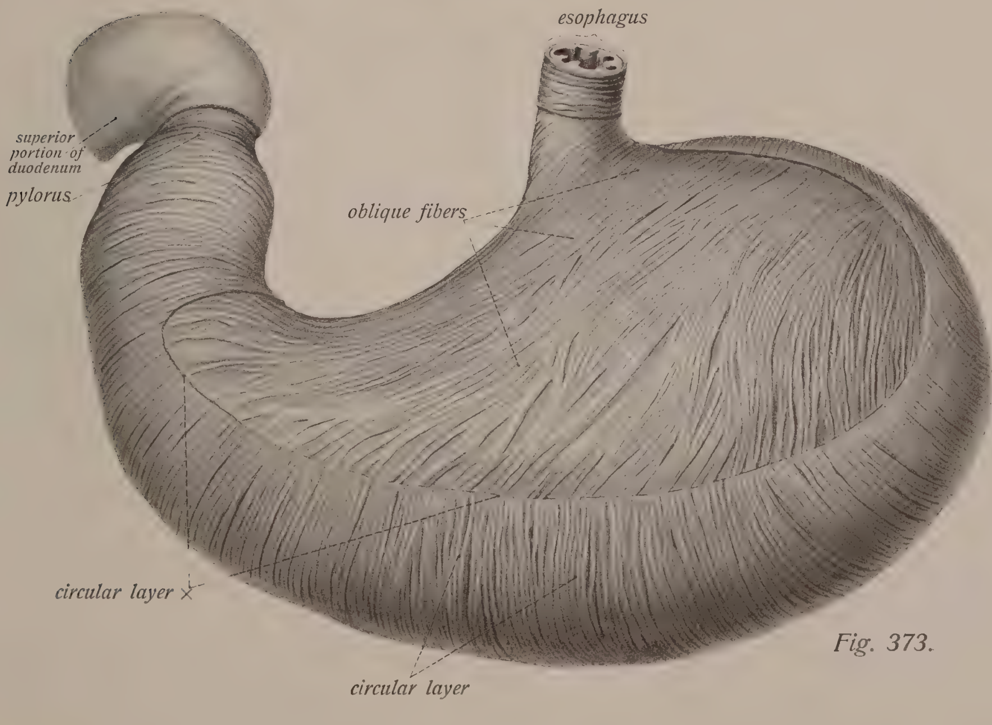

Fig. 373.

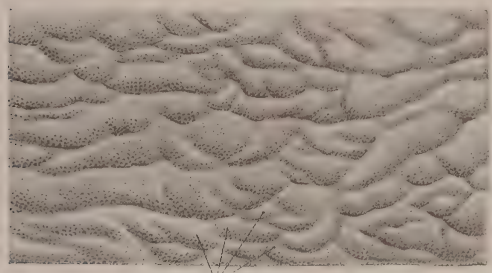

Fig. 374.

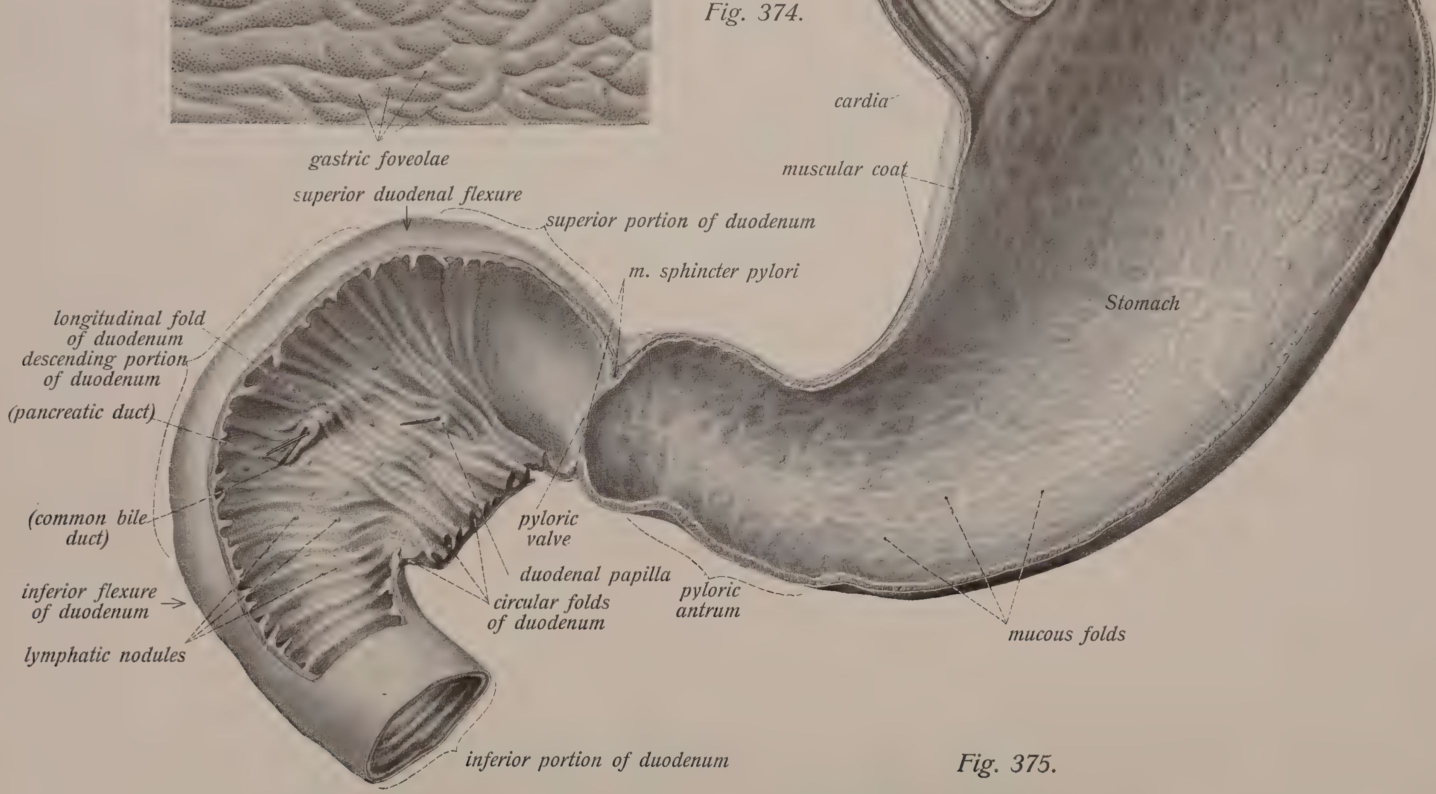

Fig. 375.

The gastric musculature (Figs. 372 and 373) consists exclusively of non-striated fibers, which in general are arranged in three layers, although these layers partly intermingle and cannot be demonstrated in all portions of the organ. The middle layer, composed of circular fibers, the *circular layer*, is the thickest and extends throughout the entire length of the stomach, forming a thickening at the pylorus, the *m. sphincter pylori*. The outer longitudinal layer is the immediate continuation of the longitudinal musculature of the œsophagus and is chiefly developed at the lesser curvature, from which it radiates obliquely to become lost toward the fundus and the body of the stomach; in the pyloric portion it becomes thicker on the anterior and posterior walls to form the *anterior* and *posterior pyloric ligaments*. The fibers of the innermost layer are known as the oblique fibers and are well developed only in the region of the fundus and body and run from the left side of the cardia over the anterior and posterior walls to the greater curvature, crossing the fibers of the circular layer obliquely and partly interlacing with them.

In the contracted or semicontracted condition of the stomach (Fig. 375) the mucous coat is thrown into tortuous longitudinal folds, whose direction is most distinct toward the pyloric portion. They are interrupted by coarser and finer systems of transverse folds, so that small areas of mucous membrane are formed, which measure 2 or 3 millimeters in diameter and are known as *gastric areas*. All these systems of folds gradually disappear during the distention of the stomach. At the pylorus the mucous membrane forms a circular fold over the m. sphincter pylori, the *pyloric valve* (Fig. 375).

The gastric mucous membrane varies in color from reddish to light gray according to the amount of contained blood. In the stage of marked congestion (the condition during digestion) the superficial veins are visible. The orifices of the gastric foveæ appear as fine points (Fig. 374) which can be distinctly recognized only with the aid of a lens.

The pharynx receives its blood-supply from the ascending pharyngeals (from the external carotids), from the descending pharyngeals and pterygopalatines (from the internal maxillary), and from the ascending palatines (from the external maxillary (facial)). The veins of the pharynx form the pharyngeal venous plexus, which empties into the internal jugular or into the common facial vein. The nerves of the pharynx come from the pharyngeal plexus formed by the pneumogastric, glossopharyngeal, and sympathetic nerves.

The cervical portion of the œsophagus receives arterial branches from the inferior thyreoids (from the subclavian); the thoracic portion is supplied by branches arising directly from the aorta (the œsophageal arteries); and the abdominal portion by branches of the arteries along the lesser curvature of the stomach (see below). Its nerves are the two vagi which form an œsophageal plexus.

The stomach receives four large arteries, the gastrica sinistra (gastric) and dextra (pyloric) and the gastroepiploica sinistra and dextra; the first two run toward each other along the lesser curvature, while the last two hold a similar relation to the greater curvature. All these vessels originate from the cœliac artery, but from different branches of it, only the gastrica sinistra (gastric), which also supplies the abdominal portion of the œsophagus, arising directly from the cœliac trunk. The similarly named gastric veins flow directly or indirectly into the portal vein, usually through the splenic. The lymphatics empty into the cœliac lymphatic glands. The nerves of the stomach come from the two pneumogastrics as well as from the cœliac plexus of the sympathetic.

THE MIDGUT OR SMALL INTESTINE (INTESTINUM TENUE).

The *small intestine* (Figs. 371, 376, 378, and 408) is a cylindrical tube about 6.5 meters long which commences at the pylorus and gradually but constantly diminishes in caliber as it passes downward to empty into the colon.

FIG. 376.—A portion of the jejunum, opened along the line of the attachment of the mesentery and spread out.

FIG. 377.—A portion of the ileum similarly treated.

FIG. 378.—A portion of the lower loop of the ileum, cut open along the line of the attachment of the mesentery, showing Peyer's patches.

It is composed of two chief portions: (1) the duodenum, which is firmly attached to the posterior abdominal wall, and (2) the freely movable larger portion, the mesenterial intestine, so called on account of its possessing a mesentery (see page 73). the mesenterial intestine is further divided into the *jejunum* and the *ileum*, which pass into each other without demarcation

The small intestine is an almost exactly cylindrical tube whose caliber is about one-third less at its termination than at its beginning. With the exception of a portion of the duodenum, it is completely invested by peritoneum, which forms its serous coat (Fig. 371) and is separated from the underlying intestinal musculature by a thin layer of subserous tissue. The peritoneal laminæ forming the mesentery are separated by a narrow interspace (Figs. 376 and 377) and insert into the posterior part of the intestinal circumference.

The average thickness of the wall of the small intestine is not great and naturally varies according to the degree of contraction. The muscular coat (Fig. 371) is composed of a continuous outer longitudinal and of an inner circular layer. The remaining coats are the submucous and the mucous, the latter possessing a lamina muscularis mucosæ, as is the case throughout the entire digestive tract.

(For further details concerning the histology of the intestinal wall see the Sobotta-Huber "Atlas and Epitome of Normal Histology.")

The mucous membrane of the small intestine contains short tubular intestinal glands and also presents small filiform projections, 0.5 mm. in length, the *intestinal villi*. These are peculiar to the small intestine and are found throughout its entire length, giving the surface of the mucous membrane a characteristic velvety appearance (Fig. 376). With the exception of a small portion of the duodenum the submucosa contains no glands.

The mucous membrane is further characterized by being thrown into transverse folds known as the *circular folds* (*valvulæ conniventes Kerckringii*) (Figs. 376 to 378). They commence at the superior duodenal flexure* and extend to the termination of the small intestine, but toward the ileum (Figs. 377 and 378) they gradually become fewer and lower, and occur in the terminal portion of the ileum only as isolated structures. They are produced by foldings of the mucous membrane but not of the remaining intestinal tunics, so that the folds are visible only upon the inner surface of the intestine. They rarely extend throughout the entire circumference, usually being sickle-shaped (particularly in the ileum) or extending over but slightly more than half of the intestinal wall.†

* The superior portion of the duodenum has either no valvulæ conniventes or merely indications of them.

† The circular folds are not obliterated in the distended intestine. When the viscus is contracted, as is frequently the case in the cadaver, indistinct longitudinal folds may be observed which disappear immediately upon distending the bowel, the only permanent longitudinal fold which is independent of the degree of distention being the longitudinal fold of the duodenum.

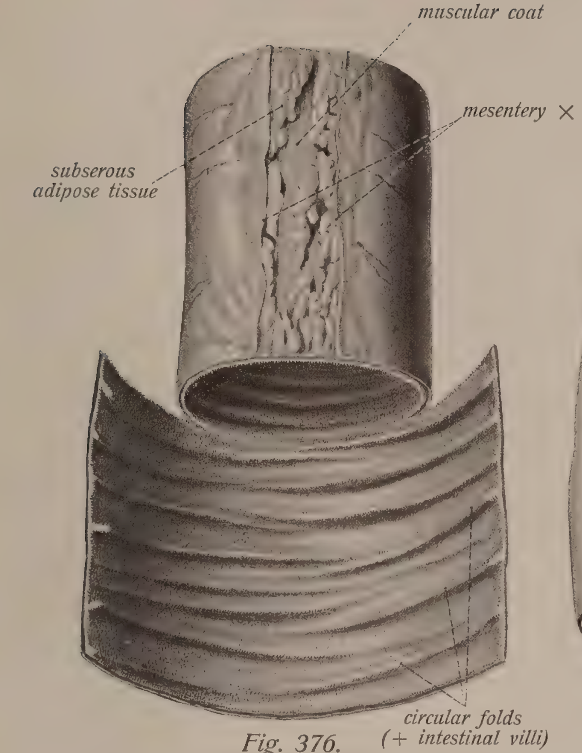

Fig. 376.

Fig. 377.

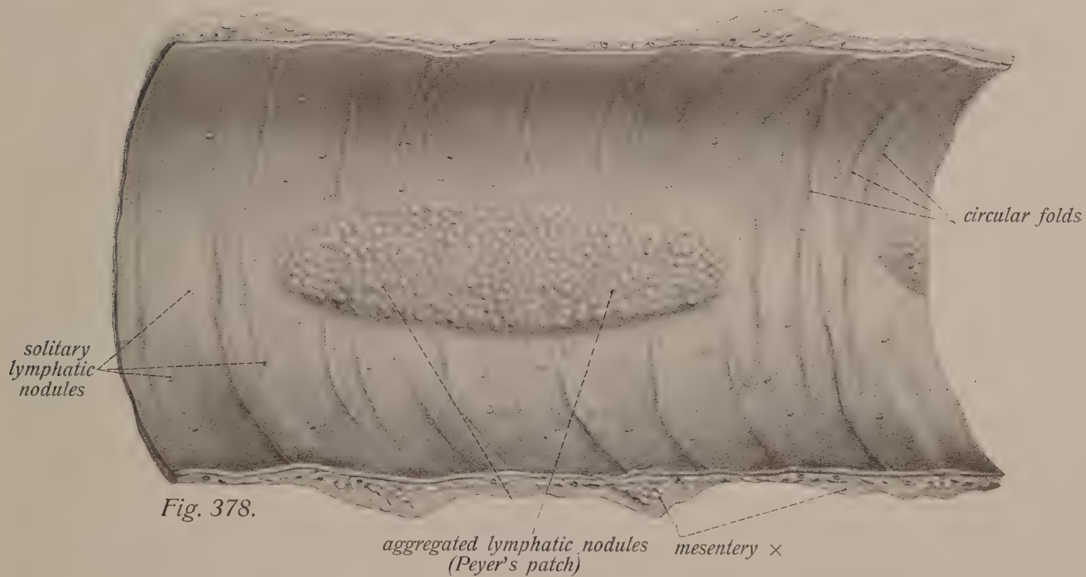

Fig. 378.

The mucous membrane of the small intestine, especially that of the ileum, contains a great number of lymphatic structures. These are found both as *solitary lymphatic nodules* about the size of a millet-seed (Fig. 377) and as groups of the same which form placques several centimeters in length (Fig. 378). The latter are known as *aggregated lymphatic nodules* (Peyer's patches) and occur only in the ileum.

THE DUODENUM.

The *duodenum* (Figs. 375, 392 to 394, and 413) was originally so named because its length was supposed to correspond to the breadth of twelve fingers placed side by side. Its shape is approximately that of a horseshoe, the concavity toward the left accommodating the head of the pancreas. It commences at the pylorus and extends to the duodenojejunal flexure.

It may be divided into a superior portion, a descending portion, and an inferior portion. The *superior portion* is the first part of the duodenum and runs almost directly from before backward to become continuous with the nearly vertical descending portion at the superior duodenal flexure (Fig. 375). The inferior duodenal flexure connects the descending with the inferior portion, the upper portion of the latter being almost horizontal, and forming what is sometimes termed the horizontal portion of the gut, while its termination bends upward and to the left, forming the ascending portion.

The relations of the duodenum are somewhat complicated (Figs. 392 to 394 and 413). It is in contact with the following organs: the stomach and gall-bladder (superior portion), the liver (superior and descending portions), the pancreas (concavity of descending portion), the inferior vena cava, the right kidney and suprarenal body (descending portion). The inferior portion lies in front of the vertebral column and aorta and behind the root of the mesentery (see page 76). The superior and shortest portion is the only part of the duodenum which is situated directly behind the anterior abdominal wall as the direct continuation of the stomach,* the descending portion being concealed by the transverse colon and the inferior portion being in contact with the posterior abdominal wall behind the mesentery. The superior mesenteric vessels pass in front of the inferior portion, and the portal vein, arising behind the head of the pancreas (see page 62 and section upon "Angiology"), is posterior to the superior portion.

With reference to the skeleton the junction of the superior portion with the pylorus corresponds to the disc between the last thoracic and the first lumbar vertebra, the superior portion itself being opposite to the first lumbar vertebra. The descending portion runs downward on the right side of the lumbar vertebral column to the (third or) fourth lumbar vertebra, while the inferior portion passes upward over the (fourth and) third to the second lumbar vertebra, the duodenojejunal flexure being situated at the left side of the body of the second lumbar vertebra. The peritoneal investment of the duodenum is incomplete, so much of the inferior portion as lies behind the root of the mesentery and the part of the descending portion situated behind the transverse colon having no peritoneal covering whatever; the intervening portion, however, receives a reflection upon its anterior surface from the ascending mesocolon. The only parts receiving a partially complete peritoneal envelope are the superior and the descending portions.

* Even this portion is largely concealed by the right lobe of the liver, and the entire superior portion is consequently invisible until this lobe is raised upward.

In general the duodenum presents the typical characteristics of the small intestine, and especially those of the jejunum, its peculiarities, in addition to its situation and relation to the peritoneum, being as follows: Its superior portion has no valvulæ conniventes, as these do not usually make their appearance until the superior duodenal flexure is reached; in the submucosa of this superior portion, however, large numbers of duodenal (Brunner's) glands occur (Fig. 371). These are irregular compound glands varying in size up to that of a hemp-seed; they extend downward for a variable distance, but are always absent in the inferior and usually also in the descending portion of the viscus.

The descending portion of the duodenum contains the orifices of the common bile-duct and of the pancreatic duct. The common bile-duct, known as the *ductus* (*communis*) *choledochus* (see page 61), traverses the intestinal wall obliquely, and produces, just before its termination, a perpendicular fold of mucous membrane, the *longitudinal fold of the duodenum*, at the lower portion of which the ductus choledochus and pancreatic duct empty either by a common orifice or by two openings separated by a transverse fold. Both ducts usually unite shortly before their termination, causing a slight elevation characterized by delicate folds of mucous membrane, the *duodenal diverticulum* (*diverticulum of Vater*). The longitudinal fold crosses the valvulæ conniventes at right angles, is rounded and but slightly elevated, and is the only permanent longitudinal fold throughout the entire small intestine. It is situated at the middle of the posterior surface of the duodenum. Somewhat nearer the stomach and more medially is a small wart-like elevation known as the *duodenal papilla* (*papilla of Vater*), upon which may sometimes be seen the orifice of the somewhat variable accessory pancreatic duct (see page 63). With the exception of its position and relations to the peritoneum the inferior portion of the duodenum differs in no respect from the jejunum, into which it passes without demarcation at the duodenojejunal flexure, which turns rather sharply forward and downward.

The layers of the duodenal wall (Fig. 371) are similar to those of the small intestine in general. The longitudinal musculature of the ascending portion is reinforced by a broad flat band arising close to the abdominal aorta from the crus of the diaphragm, and known as the *m. suspensorius duodeni* (*muscle of Treitz*); it serves to maintain the duodenojejunal flexure in position.

THE MESENTERIAL INTESTINE.

The *mesenterial intestine*, in contrast to the firmly fixed duodenum, is a freely movable portion of the intestine suspended by a broad mesentery and capable of assuming a variety of transverse oblique or almost vertical coils* (Figs. 408 and 409). It is situated chiefly in the mesogastric and hypogastric regions. The upper coils are usually those of the jejunum, the lower those of the ileum. The commencement of the mesenterial intestine which follows immediately upon the duodenojejunal flexure, and its termination emptying into the colon, have the shortest mesentery, and since the entire surface of this portion of the bowel is enveloped by peritoneum, with the exception of the narrow insertion of the mesentery, it forms a smooth and cylindrical tube.

The *jejunum* commences at the duodenojejunal flexure and gradually passes into that portion

* Five chief coils are usually differentiated in the small intestine, but they are subject to great variation.

of the small intestine which is termed the ileum, being distinguishable from this by a number of relative characteristics, although there is no sharp demarcation between the two portions. It is situated in a general way in the hypogastric regions (particularly in the left) and partly in the lateral abdominal (especially in the left) and umbilical regions (Fig. 408). It is larger in caliber than the ileum (3.5 to 4 cm.) and has thicker walls, larger circular folds, and longer villi, but, on the contrary, contains fewer lymphatic structures and no Peyer's patches whatever.

The more slender *ileum* (which has a caliber of but 2.5 cm. at its termination) occupies the lower halves of the hypogastric and lateral abdominal regions (particularly the right) (Fig. 408); in the female a coil usually lies in the recto-uterine pouch and in the male in the rectovesical fold, consequently in the true pelvis in both instances. The lower transverse coil of the ileum which empties into the colon has a rather constant position. It passes almost transversely across the right psoas or ascends slightly from left to right and from before backward to its termination in the right iliac fossa, its mesentery gradually becoming narrower. The circular folds are almost entirely wanting from the lower portion of the ileum, but Peyer's patches are frequent in this situation and rarer in the upper portion; they are frequently of considerable size (10 to 12 centimeters in length), and are always found opposite the mesenteric attachment and in the long axis of the bowel. Over their surface the villi are rare or entirely wanting. The solitary follicles also larger in the ileum than in the jejunum.

THE ENDGUT.

The endgut is composed of the large intestine and of the rectum.

THE LARGE INTESTINE.

The *large intestine* (Figs. 379 to 383, 408 to 410) is an approximately cylindrical tube from 120 to 150 cm. in length and of variable width. It is composed of two main portions: the *cæcum*, with the *vermiform appendix*, and the *colon*. These two portions, exactly alike and not sharply demarcated, are arranged in a large horseshoe loop about the small intestine, the large intestine becoming continuous with the rectum on the left. The general characteristics of the large intestine are as follows: It is the widest segment of the gut (in the restricted sense of the latter word); its caliber is greatest at the cæcum and diminishes toward the rectum; its wall when viewed from without is not smooth, like that of the small intestine, but usually exhibits sacculations (*haustra*) due to constrictions produced by three longitudinal muscular bands, known as the bands of the colon, which extend throughout the entire length of the large intestine (with the exception of the rectum). They begin in the cæcum at the base of the appendix and extend along the colon at about equal distances from each other, as smooth glistening bands about 8 mm. wide, which do not follow the configuration of the sacculations. The band situated at the place corresponding to the mesenteric insertion is termed the *mesocolic band*, the opposite one the *free band*, and the third the *omental band*, since it corresponds to the site of the adhesion of the great omentum to the transverse colon (see page 75). The sacculations disappear after the removal or complete relaxation of the bands.

The outer surface of the large intestine is further characterized by subserous accumulations

FIG. 379.—The cæcum and appendix together with the terminal part of the ileum seen from behind.

FIG. 380.—The transverse colon cut transversely, seen from the cut surface.

FIG. 381.—A portion of the transverse colon seen from in front and below.

The right end of the piece has been cut open and spread out.

FIG. 382.—The cæcum with the appendix and the lower portion of the ileum.

The cæcum is distended and its lateral wall has been removed. An incision has been made in the wall of the appendix and a sound (*) passed through it into the cæcum.

FIG. 383.—The cæcum and terminal part of the ileum divided by a frontal section.

The appendix has been cut off near its root and a sound (*) introduced into its lumen.

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of fat which hang down from the region of the omental and free bands as pedunculated irregular lobulated appendages enveloped by serous membrane. They are known as the *epiploic appendages* and are subject to manifold individual variations in number, size, and shape.

The interior of the large intestine exhibits transverse semicircular folds, the *semilunar folds*, which correspond to the constrictions between the sacculations. As a rule, their length corresponds to the distance between two bands, but they may be somewhat longer. In contrast to the circular folds of the small intestine, these folds include the entire thickness of the intestinal wall, since the constrictions contain circular muscular fibers, and since the sacculations gradually disappear during relaxation of the bands the semilunar folds may become correspondingly indistinct, portions of the colon thus occasionally coming to resemble the small intestine in appearance.

The mucous membrane of the large intestine is smooth and has no villi. The small circular orifices of the intestinal glands, which are especially large, increase in size toward the rectum, and are not visible without the aid of a lens. Solitary lymph follicles are also present in moderate numbers.

(For the finer differences from the small intestine and for further details concerning the wall of the large intestine see the Sobotta-Huber "Atlas and Epitome of Normal Histology.")

The muscular coat of the large intestine consists of an outer longitudinal layer, which is markedly thickened at the bands and but feebly developed between them, and of a continuous circular layer.

The *cæcum* (Figs. 379, 382, and 383) is that portion of the large intestine which is situated below the orifice of the ileum. It is about 7 cm. long, and equally as wide (6 to 8 cm.), consequently presenting an approximately spherical shape. It is the widest portion of the entire large intestine and upon its inner wall presents a valve at the orifice of the ileum, the *valvula coli, ileocæcal valve* (*valve of Bauhin, of Tulp.*), formed by two folds of mucous membrane which are termed the upper and the lower lip of the valve. They are formed not only of the mucous membrane but also of the two muscular layers of the ileum, and are so placed that they project into the cæcum. Their surfaces, which are directed toward the large intestine, have the character of the mucous membrane of that portion of the intestine, while those which are turned toward the lumen of the small intestine are covered with villi to the edge of the valvular orifice. When open the lips of the valve are separated by an elongated slit pointed at either end, and when in contact they form a tolerably complete closure between the large and small intestine. From

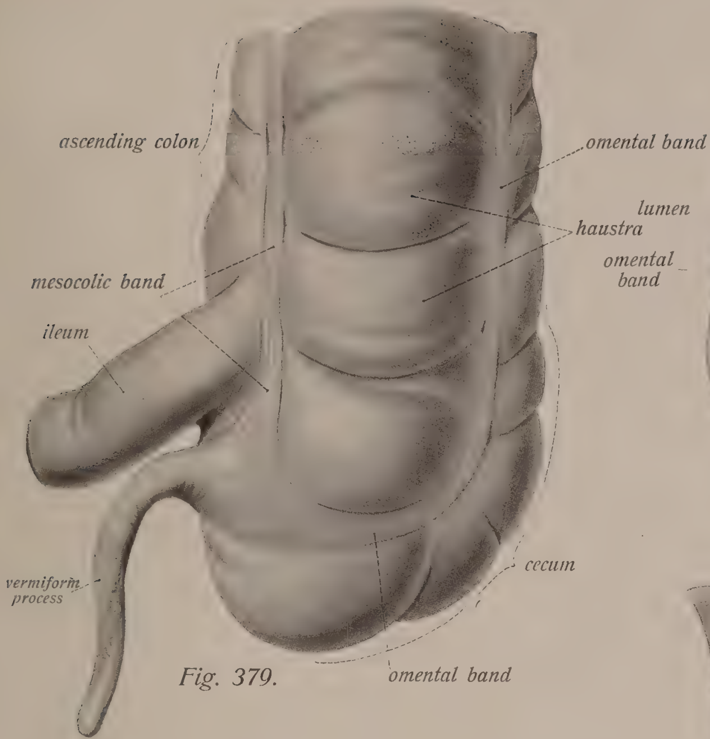


Fig. 379.

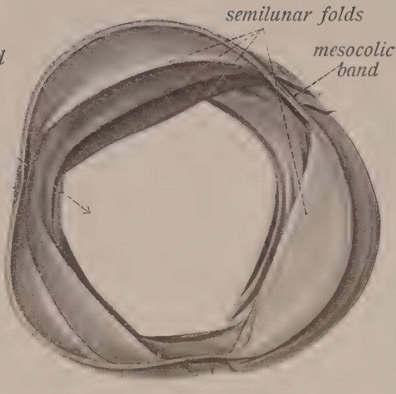


Fig. 380.

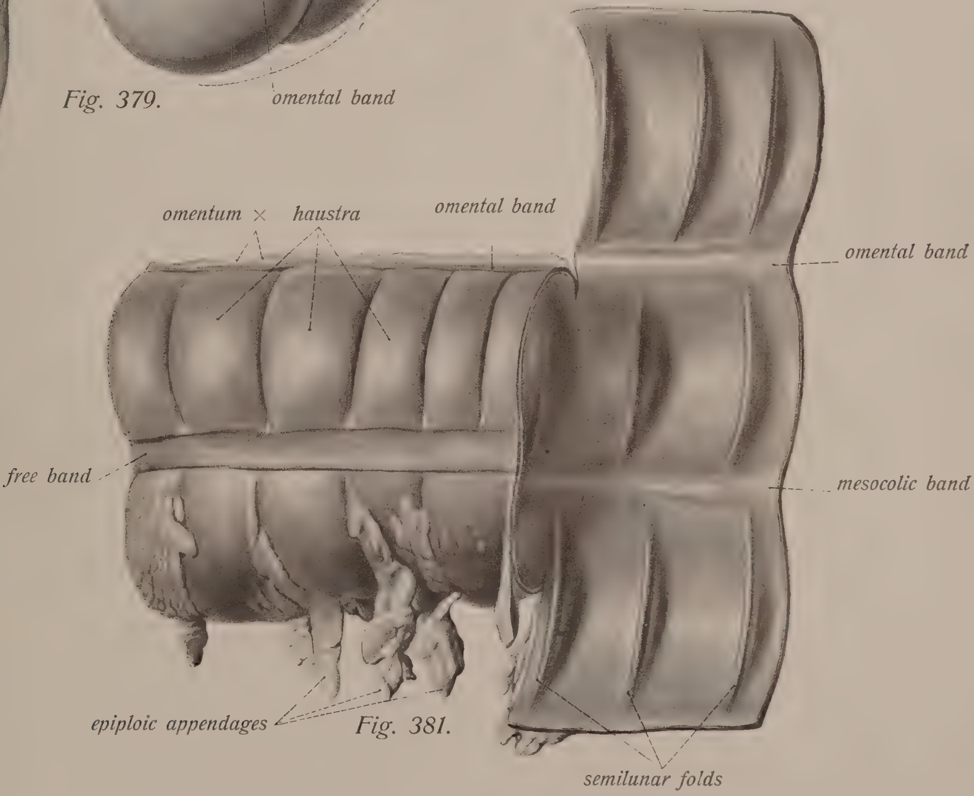
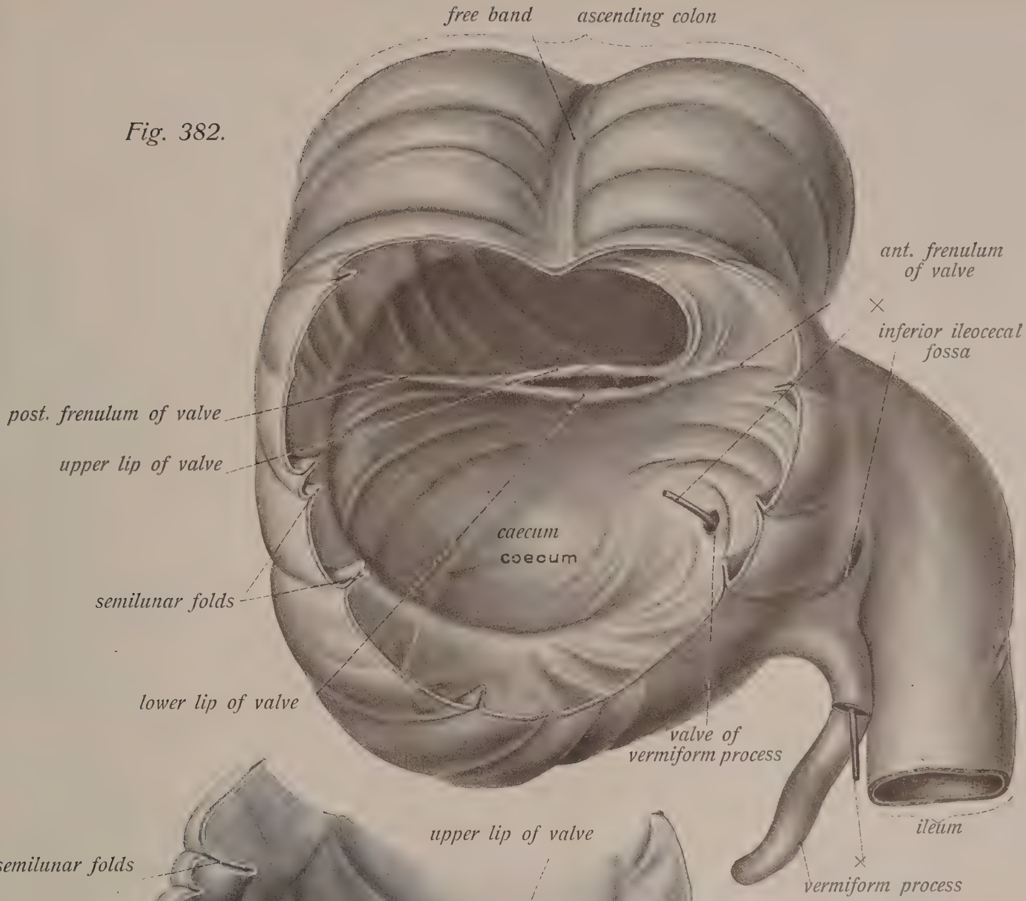


Fig. 381.

Fig. 382.



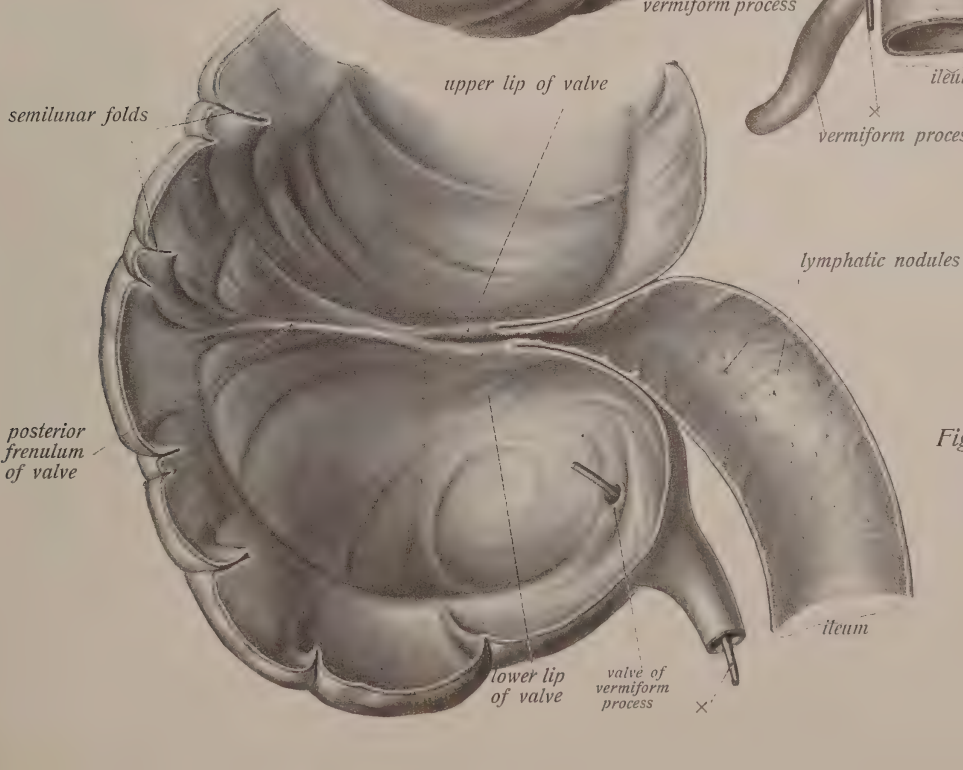


Fig. 383.

the lips of the valve semicircular folds radiate to the inner surface of the anterior and posterior walls of the cæcum, resembling the semicircular folds, except that they are longer. They are termed the frenula (anterior and posterior) of the valve and form the boundary between the cæcum and the colon.

The cæcum lies in the right iliac fossa with its lower extremity at the level of the center of the inguinal (Poupart's) ligament; when distended it is in contact with the anterior abdominal wall.

It usually possesses only a short mesentery known as the mesocæcum, and is consequently almost completely enveloped by peritoneum and is somewhat more movable than the adjacent ascending colon. It may, however, like the ascending colon, be broadly attached to the posterior abdominal wall (see also page 76). The omental band is situated upon the right side of the cæcum, and all three bands converge toward the base of the appendix.

The *processus vermiformis* or *appendix* (Figs. 379, 382, 383, and 415) of the human subject, a small, slender portion of the large intestine, is a blind rudimentary structure of very variable development. Its length varies between 3 and 20 cm. (although these extremes may in rare cases be exceeded), the average being about 9 cm. When the cæcum is empty its slightly conical apex is continuous with the appendix; but when it is distended, as in its normal condition, the appendix arises from the inner or posterior wall, and is usually curved in a most variable manner, being sometimes slightly and sometimes markedly convoluted or partly coiled up, sometimes hanging down into the pelvis or at other times situated in front of the cæcum. At its origin from the cæcum it is funnel-shaped, and its orifice is guarded by a sickle-shaped fold of variable development which is directed downward and to the right and is termed the *valve of the vermiform process* (*appendix*).

The lumen of the appendix is normally very small; the weak muscular wall is rich in lymphoid nodules and poor in intestinal glands. Indeed, the lymphoid tissue of the appendix is so dense that it seems to form a circular Peyer's patch, and the mucous membrane in consequence is relatively thick.

The *colon* (Figs. 409 and 410) is the longest portion of the large intestine and is composed of four parts: the ascending colon, the immediate upward continuation of the cæcum; the transverse colon; the descending colon; and the transition to the rectum or the sigmoid colon (s. romanum, sigmoid flexure). At the junction of the ascending and transverse colons the gut is bent at a right angle, the *right* (*hepatic*) *flexure of the colon*, and at the junction of the transverse and descending colon there is an acute *left* (*splenic*) *flexure.*

The *ascending colon* (Figs. 409 and 410) passes almost vertically upward, in front of the right quadratus lumborum and in immediate contact with the right kidney, to the lower surface of the right lobe of the liver, where it produces the colic impression (see page 59). It lies chiefly in the right lumbar, lateral abdominal, and hypochondriac regions, is usually distended in the cadaver, and has very well-marked sacculations. When markedly distended, only a portion of the ascending colon is in contact with the anterior abdominal wall. Its free band is on its anterior surface, its omental band on its lateral, and its mesocolic band upon its medial surface. Only the anterior and lateral walls of the ascending colon possess a peritoneal investment (see also page 76).

FIG. 384.—Mucous membrane of the rectum, four times enlarged.
FIG. 385.—The rectum seen from in front.
FIG. 386.—The rectum laid open lengthwise.

The *transverse colon* (Figs. 408, 409, and 410) has a relatively long mesentery and is freely movable. It passes almost transversely across the upper part of the umbilical region from the right to the left hypochondriac region, immediately behind the anterior abdominal wall, from which it is separated only by the adherent great omentum. Since the left flexure is higher than the right, the transverse colon ascends slightly from right to left, and at the same time it describes an arch, the convexity of which is anterior, since the transverse mesocolon is longest in the middle and shorter at the ends toward the flexures.

The upper border of the transverse colon is in contact with the liver, the gall-bladder, the greater curvature of the stomach, and the spleen. The coils of the small intestine are below it, while behind it are situated the duodenum (inferior and descending portion) and part of the pancreas. It also is usually distended in the cadaver and frequently so markedly so that it overlaps the stomach and displaces the large omentum. Its free band is on its inferior surface, its omental band on its upper anterior, and its mesocolic band on its upper posterior surface. Epiploic appendages are usually found only along the free band and its sacculations are very distinct, although occasionally not so well developed as in the ascending colon.

The *descending colon* (Figs. 409 and 410) commences with the splenic flexure at the lower pole of the spleen and in front of the left kidney. It is situated in the left hypochondriac, lumbar, and lateral abdominal regions in front of the left quadratus lumborum and at the outer border of the left kidney; it has no mesentery and is in immediate contact with the posterior abdominal wall. Unlike the ascending colon the descending colon as well as the splenic flexure is usually empty in the cadaver. Above it is in relation with the tail of the pancreas, and below, in the left iliac fossa, it passes in front of the external iliac vessels to become directly continuous with the sigmoid colon. In the cadaver it is usually separated from the anterior abdominal wall by coils of the small intestine. The arrangement of its bands is precisely like that in the ascending colon, its caliber is considerably smaller, and its sacculations are not so pronounced and may be even almost entirely absent for a certain distance.

The *sigmoid colon* (Figs. 409 and 410) is the immediate continuation of the descending colon, from which it is distinguished by the possession of a broad mesentery, the sigmoid mesocolon, and by its consequent mobility. In other respects it is exactly like the descending colon except that the sacculations continue to become more scanty and the bands become broader as the rectum is approached. It usually consists of two parallel limbs which are slightly curved and pass transversely in front of the left psoas, and below the promontory it passes quite gradually into the rectum. Its position is variable, but is usually arranged in a loop which is directed upward, although one of the branches of the loop may lie in the true pelvis. When markedly distended a portion of varying length is frequently in contact with the anterior abdominal wall.

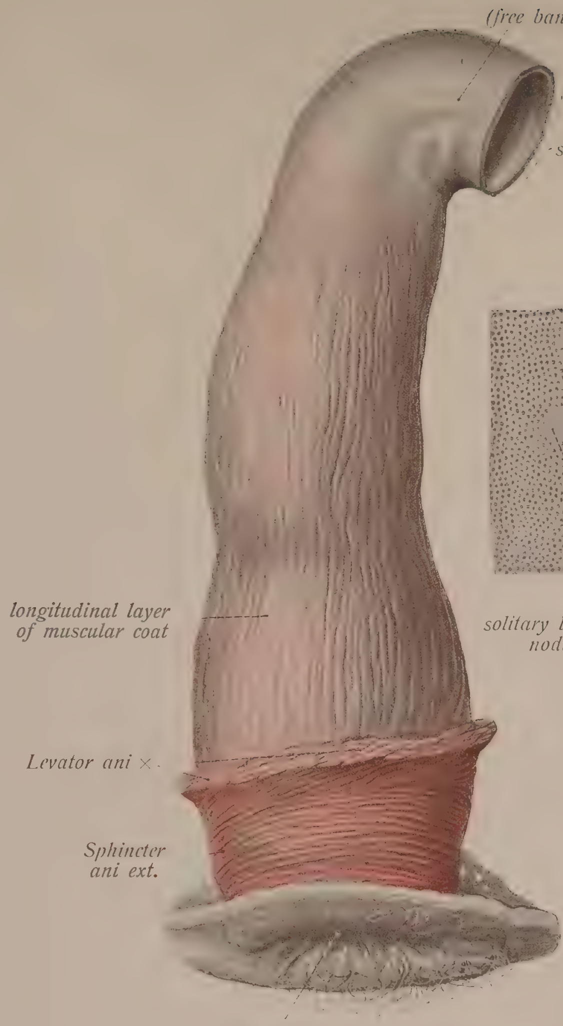


Fig. 385.

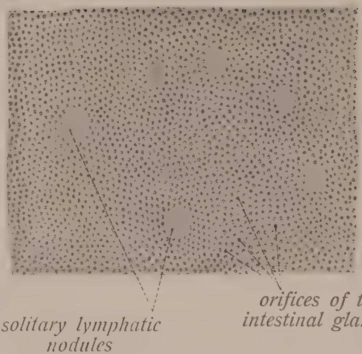


Fig. 384.

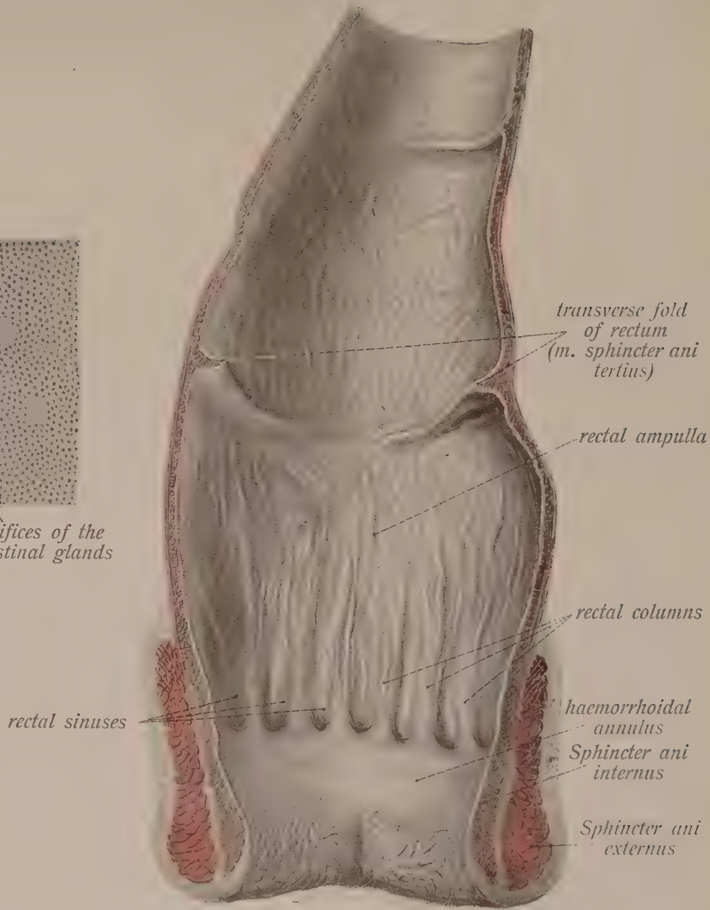


Fig. 386.

THE RECTUM.

The *rectum* (Figs. 384 to 386, 481, 482, and 502) extends from the colon to the anus. Its upper end lies somewhat to the left of the median line and is continuous with the sigmoid colon immediately below the promontory of the sacrum, the mesentery becoming much narrower at its origin. It is in general a cylindrical canal, 15 to 20 cm. in length; its outer surface is smooth and consequently resembles that of the small rather than that of the large intestine, this condition being due to the fact that the longitudinal bands of the colon spread out upon reaching the rectum and form a continuous rather thick longitudinal muscular layer, the sacculations consequently disappearing entirely.

The rectum does not pursue a straight course in the body but exhibits a number of flexures, the chief of which lie in the sagittal plane, the upper one corresponding to the concavity of the sacrum. It is concave anteriorly and convex posteriorly and is known as the *sacral flexure*. This upper curved portion of the rectum is continuous with a lower curvature, the *perineal flexure* (Figs. 482 and 483), which is situated in the same plane, and is concave (superiorly and) posteriorly and convex (inferiorly and) anteriorly; it is produced by the passage of the rectum over the tip of the coccyx. The terminal portion of the rectum, which ends at the anus, is called the *anal portion*.

In addition to these double sagittal curves the upper portion of the rectum also presents a curvature in the frontal plane. From its junction with the sigmoid colon, somewhat to the left of the median line, the rectum passes first to the right of the median line and then shows a slight curvature, the convexity of the curve being directed toward the left. Not until it reaches the level of the coccyx does the rectum lie exactly in the median line.

The part of the rectum above the anal portion presents, especially in the distended state, a distinct fusiform dilatation known as the *rectal ampulla* (Fig. 386). The posterior rectal wall is in contact with the anterior surface of the sacrum and coccyx, and only in its upper portion does the rectum possess a complete peritoneal investment (Fig. 481) and a mesentery which extends as low as the second sacral vertebra and is called the *mesorectum*. Below this point the posterior surface of the rectum has no peritoneal coat for 12 to 14 cm., so that the longitudinal musculature of the rectum in this location is in contact with the vessels and nerves situated upon the anterior surface of the sacrum and coccyx. On the anterior surface the peritoneal covering extends much further down, reaching about the level of the last sacral vertebra, but below this, the rectum, and particularly the ampulla, is completely free from peritoneum (about 5 cm.).

In the female the anterior wall of the rectum is in relation with the vagina and uterus (Figs. 502 and 503), in the male with the bladder, seminal vesicles, and the prostate gland (Figs. 482 and 483). Between these parts, so far as the peritoneal covering of the anterior rectal wall extends, is the recto-uterine pouch in the female and the rectovesical pouch in the male (see page 77). Coils of small intestines may lie in these pouches and consequently come into relation with the anterior rectal wall. In its inferior non-peritoneal portion the anterior rectal wall is in immediate contact with the vagina in the female and with the bladder and prostate in the male.

The inner surface of the rectum is in general smooth, in contrast with that of the other

portions of the large intestine, but the mucous membrane is raised into a variable number of *transverse folds*.* A tolerably constant fold, particularly well developed upon the right rectal wall, occurs at about 6 to 8 cm. above the anus (Fig. 386). In the anal portion the mucous membrane forms 6 to 10 longitudinal folds or ridges known as the *rectal columns* (*columns of Morgagni*). They commence about 2 or 3 cm. above the anus and terminate in the *hemorrhoidal annulus* (Fig. 386), a circular elevation immediately above the anal orifice, corresponding to the position of the external sphincter (see page 159). Between the rectal columns corresponding sacculations occur, each of which is known as a *rectal sinus* (*sinus of Morgagni*). The hemorrhoidal annulus contains the venous anastomoses of the hemorrhoidal plexus. The intestinal glands reach their greatest length in the rectal mucous membrane and their orifices may be recognized as fine points by the naked eye (Fig. 384). In the anal portion the mucous membrane gradually assumes the characteristics of the integument, with which it is directly continuous.

The *anal orifice* or *anus* (Fig. 385) is formed by distinctly pigmented skin rich in sebaceous glands and always furnished with large hairs in the male. When closed its integument is thrown into radiating folds.

The musculature of the rectum is very strong and at the anal orifice becomes associated with striated muscle (see page 159). The circular layer becomes thicker at the lower end of the rectum, about 3 cm. above the anus, this thickening of the involuntary circular fibers forming what is termed the *sphincter ani internus* (Fig. 386), in contradistinction to the voluntary *sphincter ani externus* (see page 159). A less pronounced reinforcement of the circular layer along the line of the most marked transverse fold, is termed the *sphincter ani tertius*.

The *rectococcygeus* is a paired muscle which arises from the anterior surface of the second or third coccygeal vertebra and passes to the posterior surface of the rectum, radiating into its longitudinal muscular layer, and fibers of the involuntary rectal musculature frequently pass to the prostate in the male and to the uterine ligaments in the female.

The upper portion of the duodenum is supplied by the superior pancreaticoduodenal artery from the cœliac axis, while the lower portion receives its blood from the inferior pancreaticoduodenal artery from the superior mesenteric.

The arteries for the mesenterial intestine all come from the superior mesenteric, and that vessel also gives off the ileocolic artery to the cæcum, the colica dextra to the ascending colon, and the colica media to the transverse colon. The descending and sigmoid colons, as well as the upper portion of the rectum, are supplied from the inferior mesenteric artery by the colica sinistra and superior hemorrhoidal branches; the middle portion of the rectum is nourished by the middle hemorrhoidal branch of the internal iliac; while the anal portion receives the inferior hemorrhoidal branch of the internal pudic.

The veins of the entire intestinal tract form two main trunks which unite and constitute the portal vein (see page 62). The very abundant intestinal lymphatic vessels pass to numerous lymphatic glands situated in the mesentery, and from these the lymph passes through the intestinal lymphatic trunk to the cisterna chyli and thoracic duct (for further detail see the section upon Angiology).

The nerves of the intestine come from the pneumogastric and the sympathetic, especially from the large sympathetic cœliac ganglion; they form a small *submucous plexus* (*plexus of Meissner*) in the submucosa and a larger *myenteric plexus* (*plexus of Auerbach*) between the two muscular layers of the intestine. (For further details see the Sobotta-Huber "Atlas and Epitome of Normal Histology.")

For details concerning the development of the digestive tract the reader is referred to the special text-books upon embryology, but the main features of the development are as follows. In the fourth week of embryonic life the intestine is an almost straight tube which lies in the middle of the embryonic body cavity, the cœlom, and a shorter canal, the omphalo-

* In the empty state transitory transverse and longitudinal folds are also present in the rectum.

mesenteric duct, connects the gut with the umbilical vesicle, formed from the yolk-sac. In the sixth week the intestinal tube has become sufficiently differentiated to allow the first indications of the main divisions of the intestine to be recognized (Fig. 399). The stomach appears as a dilatation of the upper portion of the gut; its lesser curvature, however, being directed forward (and to the right), the greater one backward (and to the left), and the fundus upward and backward. The pyloric portion, situated in the median line, turns backward and to the right to become continuous with what will later be the duodenum and which already possesses its definitive form, although its convexity is directed anteriorly and to the right. In the median line it makes a sharp turn, the duodenojejunal flexure, and passes into the so-called primitive or umbilical intestinal loop. This consists of two straight almost parallel limbs which lie freely in the abdominal cavity and almost in the sagittal plane, the bend of the loop being situated in a funnel-shaped protrusion of the abdominal cavity which extends into the base of the umbilical cord. The upper limb proceeding from the duodenojejunal flexure lies to the right of the lower one and represents the main portion of the small intestine, from the end of which (*i e.*, from the bend of the loop) the omphalomesenteric duct has become constricted. Occasionally, however, a portion of this duct persists as a blind appendage of the lower end of the ilium, 5 to 10 cm. in length, and is known as the diverticulum ilei (Meckel's diverticulum).

The lower limb of the umbilical loop at its commencement (near the bend) presents a small lateral dilatation which subsequently becomes the cæcum, while the remainder of the lower limb forms the chief portion of the large intestine. Upon reaching the posterior abdominal wall the lower limb makes a rather sharp bend corresponding to the splenic flexure of the colon and passes into the tolerably straight terminal portion of the gut which is situated in front of the vertebral column and the sacrum. The upper limb of the primitive intestinal loop and the immediately adjacent portion of the lower, consequently forms the entire small intestine, while the greater part of the lower (recurrent) limb becomes the cæcum and the ascending and transverse colons. That portion of the embryonic gut below the umbilical loop and in contact with the abdominal wall is subsequently differentiated into the descending colon, the sigmoid colon, and the rectum.

In the further development of the intestinal canal the stomach is rotated in such a manner that the greater curvature, originally directed backward, is displaced toward the left, and as a result the gastric walls which were left and right now become anterior and posterior. The primitive intestinal loop soon undergoes further development, which practically consists of an inequality of growth of the two limbs. The upper limb (small intestine) grows rapidly and is soon thrown into convolutions which continually become more complex, while the lower limb (large intestine) at first remains unchanged (Fig. 400). It is not until the small intestine has become markedly convoluted and completely withdrawn from the umbilical region that the large intestine gradually changes its position in such a manner that in the third embryonic month the cæcum is near the middle of the abdomen and finally is displaced upward almost to the greater curvature of the stomach. At this time the coils of small intestine are always to the right and the large intestine to the left of the middle line. In the fourth embryonic month the cæcum passes to the right along the greater curvature of the stomach and the under surface of the liver and simultaneously downward, at first in front of the duodenum and then in front of the right kidney (Fig. 401). That portion of the large intestine which is formed from the umbilical loop is consequently gradually displaced to the right over the small intestine, so that the latter takes up a position between the two main segments of the large bowel. The hepatic flexure of the colon is formed at this time and indicates the differentiation of the ascending from the transverse colon, and the terminal portion of the large intestine is gradually displaced more and more to the left by the increasing length and convolution of the small intestine, and by the rapid longitudinal growth of one portion of it a loop is formed which later becomes the sigmoid colon.

THE LIVER (HEPAR).

The *liver* (Figs. 387 to 391, 407, 416, 417, and 455) is the largest gland of the human body. It has the shape of a flattened ellipsoid, passes almost transversely across the upper portion of the abdominal cavity, and is composed of two lobes, a much larger right lobe and a smaller left one. It is soft in consistence and has a peculiar brownish-red color.

It has a markedly convex superior surface (Figs. 387 and 388), which is also directed somewhat anteriorly, and a similarly convex posterior surface. The greater portion of the inferior surface, on the contrary, is concave and of irregular shape. The superior and inferior surfaces unite in a sharp anterior border which is rounded off toward the right end of the liver, while the posterior and inferior surfaces pass into each other without demarcation.

The lower surface (Figs. 389 and 391) possesses a characteristic form on account of the soft-

FIG. 387.—The liver with a portion of the diaphragm seen from in front.
FIG. 388.—The liver seen from above.

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ness of the hepatic tissue being influenced by the neighboring organs. It contains the *porta hepatis* (*portal fissure*) (Fig. 390), a transverse, rather deep and broad fissure which is situated almost in the middle, *i. e.*, almost equidistant from the anterior and posterior margins (but somewhat nearer the latter), and about midway between the left and right ends of the liver (but nearer the former) (Fig. 389). It gives entrance to the hepatic artery (ramus hepaticus proprius), the much larger portal vein, which has usually already divided into its two chief branches, the right and left branches, and the hepatic nerves accompanying the artery. It gives exit to the *hepatic duct* (usually in two main components*), which unites with the *cystic duct* just below the porta hepatis to form the *ductus choledochus* (communis), and it also gives passage to a number of lymphatic vessels which run to the hepatic glands (five or six) situated in the immediate vicinity. The vessels at the porta hepatis are so situated that the ductus choledochus is anteriorly and to the right, the hepatic artery anteriorly and to the left, and the portal vein posteriorly and between the two.

The vessels reach the porta hepatis by the *hepatoduodenal ligament*, and in the porta itself are surrounded by a layer of connective tissue which accompanies them and their ramifications for a certain distance, and also forms a thin layer upon the surface of the liver known as the *fibrous capsule of the liver* (*capsule of Glisson*).

In addition to the transverse porta hepatis, the inferior surface of the liver also presents two approximately parallel longitudinal fissures which pass in a sagittal direction and form an H-shaped figure with the porta hepatis, although they are much shallower than the latter. They are known as the *right* and *left sagittal fissures* (Fig. 391). The first is crossed at about its middle by the *caudate process*, so that it consists of two separated halves, an anterior, the *fissure for the gall-bladder*, and a posterior, the *fissure for the vena cava*. The left sagittal fissure is also differentiated into two portions, which are, however, directly continuous with each other at the left margin of the porta hepatis; the anterior is the *umbilical fissure* and the posterior the *fissure for the ductus venosus*.

The fissure for the gall-bladder contains the *gall-bladder* (*vesica fellea*) and is correspondingly broad and shallow; the fissure for the vena cava transmits the inferior vena cava, which is firmly adherent to the hepatic tissue and is not infrequently bridged over by a layer of connective tissue, the *ligament of the vena cava* (Fig. 389). The vena cava during its passage through the liver receives the efferent hepatic vessels, consisting of a series of lesser and two greater hepatic veins, near the superior margin of the posterior surface of the liver.

The umbilical fissure contains the obliterated umbilical vein, which forms the *round ligament* (*ligamentum teres*) of the liver, and extends to the anterior hepatic margin, where it forms a notch, the *umbilical notch*. The fissure for the ductus venosus contains the obliterated ductus venosus (ductus Arantii), which is connected with the ligamentum teres by means of the left branch of the portal vein (see page 62).

* This duct usually receives several small additional branches.

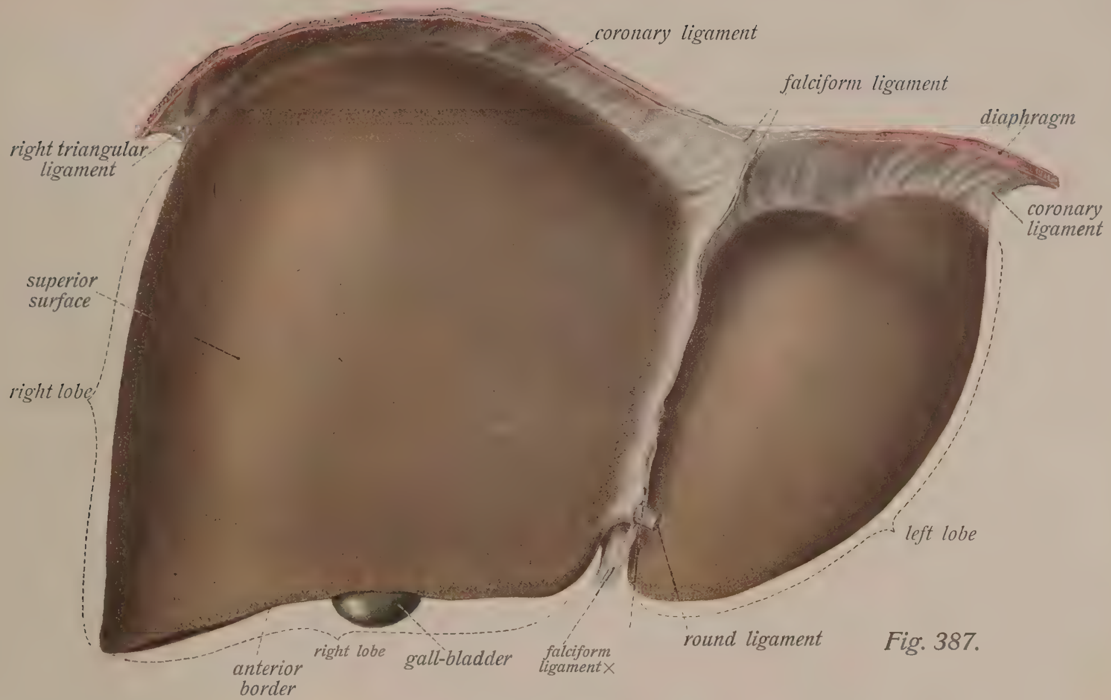

Fig. 387.

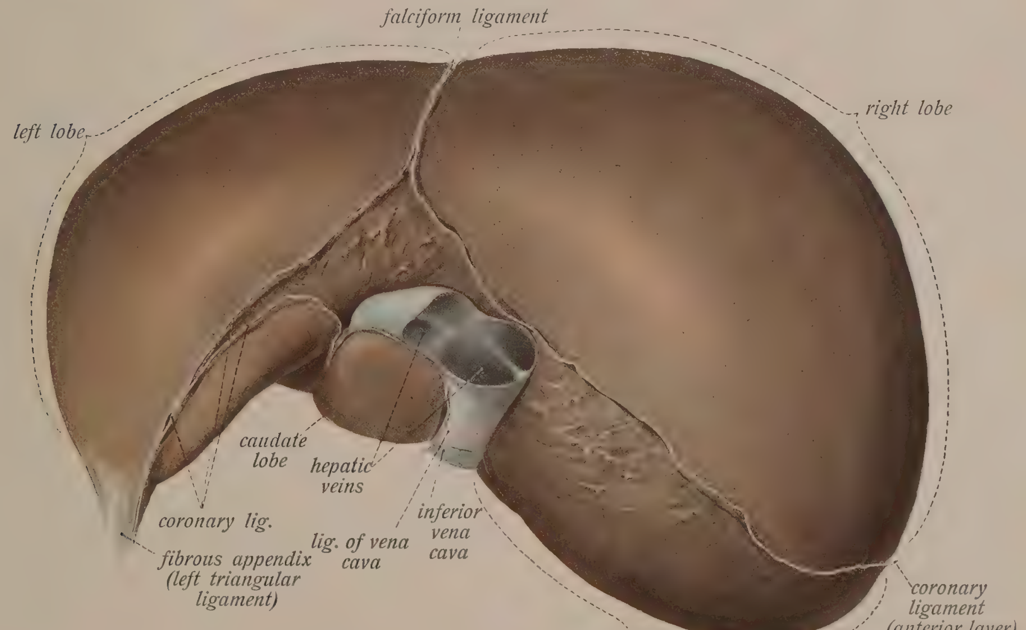

Fig. 388.

The *left lobe* of the liver is situated to the left of the left sagittal fissure. It includes only about one-fourth of the total mass of the liver, and is distinctly concave upon its inferior surface. Since this concavity is produced by the stomach, which is normally situated below the left lobe of the liver, it is called the *gastric impression*, and an *œsophageal impression* is also made upon the left lobe by the œsophagus as it passes into the cardia. Below and to the right, the lower surface of the left lobe exhibits a convexity, the *tuber omentale*,* which corresponds to the concave lesser curvature of the stomach. In the adult liver the tip of the left lobe gradually tapers out into a fibrous process, the *fibrous appendix*.

The *right lobe* of the liver includes all of the tissue to the right of the left sagittal fissure. Upon the inferior surface, however, the right lobe in a restricted sense is to the right of the right sagittal fissure, the portions of hepatic tissue between the two fissures and separated by the porta hepatis being known as the *quadrate lobe* and the *caudate* (*Spigelian*) *lobe* (Figs. 389 and 391). The former is in front of the porta hepatis toward the anterior border of the liver and is a slightly elevated rectangular area; the latter lies behind the porta hepatis, and is smaller but more prominent than the quadrate lobe, being demarcated from the surrounding hepatic tissue by deep fissures. The right and caudate lobes are connected by a rather narrow *caudate process*, which divides the right sagittal fissure into halves, and the rounded left lower angle of the caudate lobe, which is opposite the caudate process, is called the *papillary process*. The caudate lobe is situated behind the pars flaccida of the lesser omentum (see page 75) in the vestibule of the bursa omentalis (see page 83), which it completely fills.

The inferior surface of the right lobe, in the restricted sense, presents a number of markings produced by the neighboring viscera (Figs. 389 and 391). The most pronounced is the *renal impression* resulting from the right kidney and situated beside the caudate lobe; in front of this is the less distinct *duodenal impression;* to the right and separated by a flattened ridge is the *colic impression*, produced by the hepatic flexure of the colon; and the right suprarenal body usually produces an inconstant concave depression immediately beside the fissure for the vena cava. These impressions, due to the marked plasticity of the liver parenchyma, are very transitory in character and are visible in the liver removed from the cadaver only when it has been previously hardened.

Upon the upper surface of the liver the boundary between the right and the left lobes is indicated by the *falciform* (*suspensory*) *ligament*, which, passing downward from the liver surface, envelops the round ligament like a mesentery. Upon this surface the right lobe seems to be a homogeneous structure and there are no formations corresponding to the caudate or quadrate lobes. At the anterior border of the liver the previously mentioned umbilical notch forms the division between the two main lobes.

The *posterior surface* of the liver, within the boundaries of the right lobe, exhibits a broad area uncovered by peritoneum, but upon the left lobe this uncovered area is limited to the narrow space between the attachment of the two layers of the coronary ligament (see page 74, Fig. 388). The remaining portion of the liver, except the porta hepatis, is completely invested by peritoneum.

The liver substance consists of lobules which are visible microscopically, but are indistinctly

* So called because the lesser omentum (see page 75) is situated in front of it.

FIG. 389.—The liver seen from below.

FIG. 390.—The porta hepatis with the vessels and lymphatic glands.
The vena cava is divided lengthwise.

separated from each other; they are polygonal in form and about the size of a barley-corn. The center of the lobule is usually brownish-red, while the periphery is frequently of a yellowish tinge.* The liver substance is very soft and brittle.

The liver is situated in the right hypochondriac, epigastric, and left hypochondriac regions,

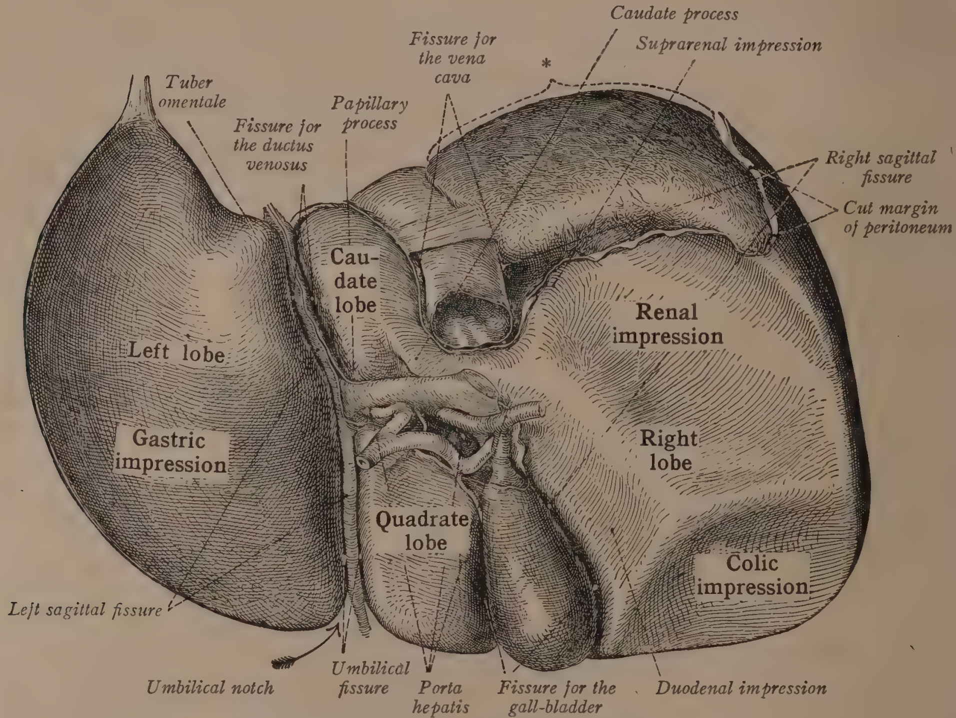

FIG. 391.—The liver seen from below. *= Surface uncovered by peritoneum.

and fills the right cupola of the diaphragm and a portion of the left one; in the middle it is in relation with the central tendon and its posterior surface is in contact with the crura of the diaphragm. It is also in relation with the viscera, which make impressions upon its lower surface, namely, the stomach, the superior and descending portions of the duodenum, the gall-bladder, the right kidney and suprarenal body, the hepatic flexure of the colon, and the inferior vena cava.

* The periphery of the lobule is of a distinct yellow, particularly in the so-called fatty liver. Since slight degrees of fatty infiltration are very frequent in the liver, the color is quite frequently noticeable in the cadaver.

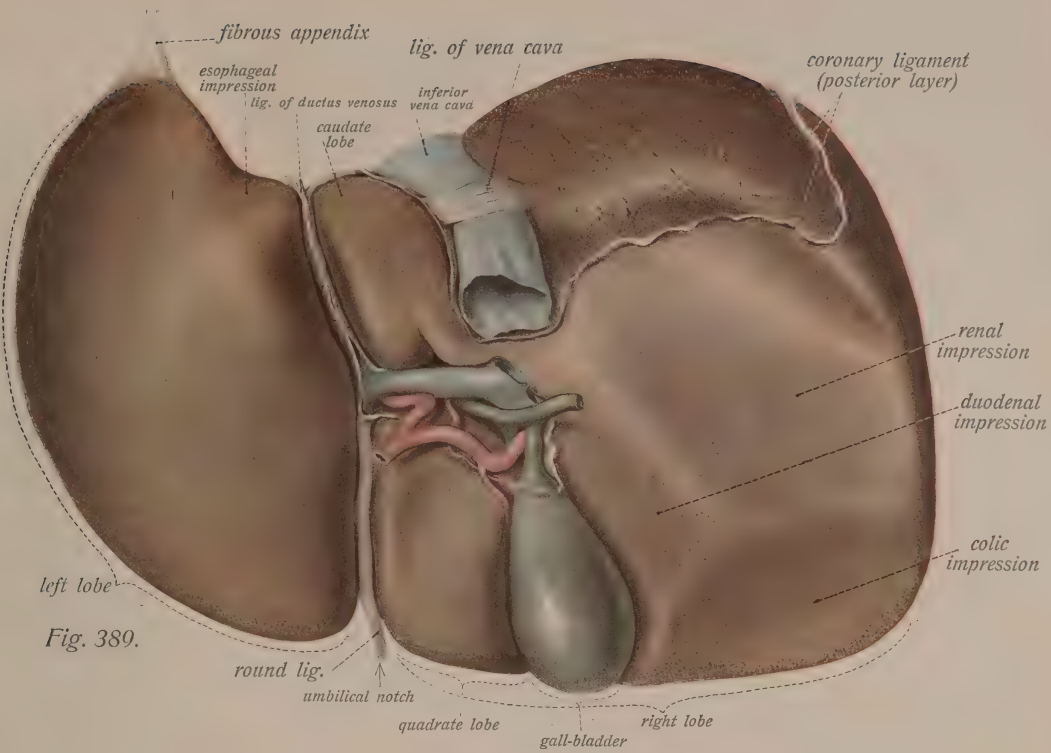

Fig. 389.

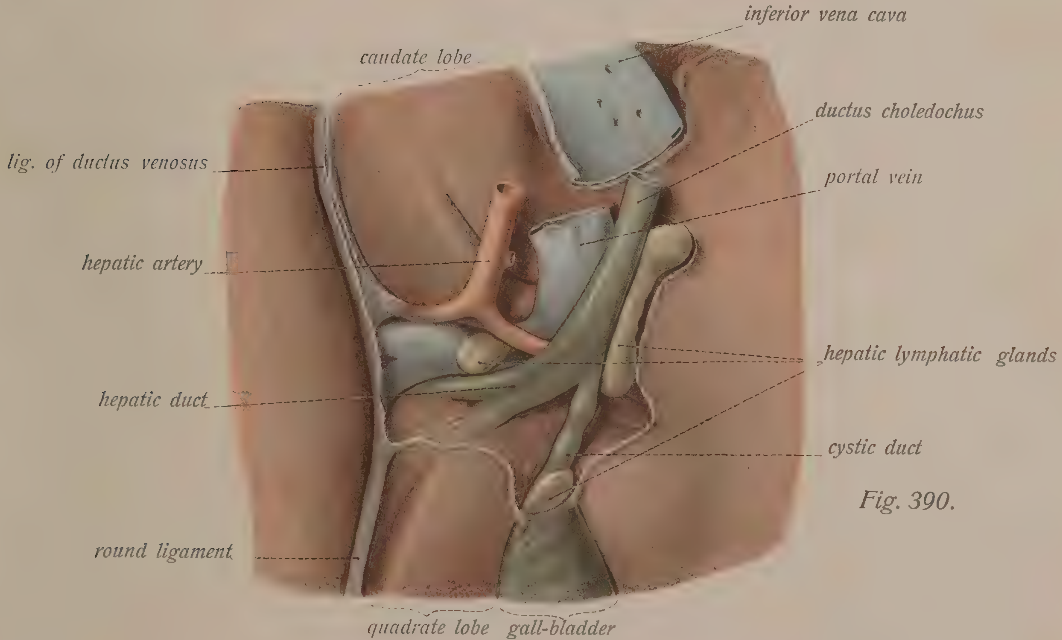

Fig. 390.

The following points indicate the relation of the liver to the skeleton. The posterior surface is opposite the ninth and tenth thoracic vertebræ. During inspiration the highest point of the liver is upon the right side in the fourth intercostal space, and its lower border follows the costal arch as far as the median line, where it is usually about three finger-breadths below the tip of the xiphoid process of the sternum. The entire right half of the liver is considerably lower than the left, and while the left lobe is completely concealed behind the left costal cartilages, the right one extends below the inferior margins of the seventh to the tenth ribs, and in this situation is immediately behind the muscular portion of the anterior abdominal wall.

The average length (transverse diameter) of the liver is 30 to 36 cm., its height is 20 to 22 cm., and its greatest thickness is 7 or 8 cm.

The left lobe is very variable in length and not infrequently extends to the spleen. In this situation the liver parenchyma terminates quite gradually in the *fibrous appendix*, in which are found *vasa aberrantia* of the liver, blind bile-ducts and their ramifications, structures which also occur in other portions of the surface of the liver, particularly in the fibrous capsule beneath the peritoneal coat and in the ligament of the vena cava. The fibrous appendix probably results from a marked atrophy of the tip of the left lobe produced in the fetus by the pressure of the growing stomach. This would also explain the varying length of this lobe in different individuals.

The *gall-bladder* or *vesica fellea* (Figs. 389, 391, 393, 394, 405, and 406) serves as a reservoir for the bile secreted by the liver, and is situated in the fissure for the gall-bladder upon the inferior surface of the viscus. It is a pear-shaped sac, usually distended with bile, and consequently of a brownish-green or green color. It presents a rounded fundus, which in the distended condition projects beyond the anterior hepatic margin, and a constricted neck, which gradually passes into the cystic duct. Between the two is the body of the gall-bladder. The relations of the gall-bladder are dependent upon those of the liver. The fundus is placed below the right ninth or tenth costal cartilage and the neck and cystic duct are directed toward the right. The upper non-peritoneal surface of the gall-bladder is connected with the liver substance by fibrous tissue; the lower surface is invested with peritoneum.

The wall of the gall-bladder is of moderate thickness and contains a weak muscular coat. In the distended state the mucous membrane is elevated in narrow rugæ, which undergo manifold decussations and give the inner surface of the gall-bladder a peculiar reticulated appearance (Fig. 395).

The *cystic duct* is the immediate continuation of the neck of the gall-bladder, and is a short irregularly cylindrical structure which turns sharply to the left near the porta hepatis and unites with the hepatic duct to form the ductus choledochus. Its caliber is smaller than that of the hepatic duct, and its mucous membrane is arranged in folds which pursue a slightly spiral course and constitute the *spiral valve* (*valve of Heister*) (Fig. 395). Corresponding to these folds the outer surface of the duct usually presents distinct constrictions.

The *ductus* (*communis*) *choledochus* arises immediately in front of (below) the porta hepatis by the junction of the hepatic and cystic ducts and runs in the hepatoduodenal ligament to the right side of and anterior to the portal vein (see page 58); it passes behind the superior portion of the duodenum to the posterior and inner wall of the descending portion, where it forms the

FIG. 392.—Pancreas and duodenum seen from in front.

The pancreatic ducts have been exposed by dissection of the pancreas in front; the duodenum has been divided longitudinally.

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longitudinal fold (see page 50) and empties into the duodenum in common with the main duct of the pancreas.

The blood-vessels of the liver hold a peculiar relation to the viscus and one that is not encountered in any other portion of the human body. The organ possesses two afferent vessels, the larger of which is the portal vein. This arises behind the head of the pancreas by the union of the superior mesenteric and splenic veins, and transmits to the liver the venous blood from the intestines, the stomach, the pancreas, and the spleen. The other vessel is the hepatic artery, which comes off from the cœliac artery and ramifies chiefly in the wall of the gall-bladder (the cystic branch), about the bile-ducts, and in the fibrous capsule of Glisson, its capillaries forming venules which empty into the intrahepatic branches of the portal vein. The hepatic veins are the efferent vessels of the liver, and their contained blood has consequently passed through two sets of capillaries, *i. e.*, first through those of the digestive tract and then through those of the liver. The lymphatics of the liver run to the hepatic lymphatic glands at the porta hepatis, from these to the cœliac lymphatic glands, and thence to the truncus intestinalis or directly into the cisterna chyli. The nerves of the liver enter the viscus with the hepatic artery as the hepatic plexus, and are furnished by the sympathetic and the pneumogastric.

The liver is developed as a protrusion of the embryonic intestinal wall at the site of the subsequent duodenum. This protrusion appears in about the third week of development and is double, the two halves subsequently fusing to form a single organ and a single duct (the hepatic or common duct). The gall-bladder arises as a lateral protrusion of the hepatic duct. In the fetus and even in the new-born the liver is enormous, being relatively much larger than in the adult.

The circulation in the liver has intimate relations to the circulation in the fetus (see page 169). The round ligament of the liver is the remains of the obliterated umbilical vein, *i. e.*, of the single vein which passes through the umbilical cord from the placenta and transmits blood laden with nutritive material from the placenta to the fetus. The umbilical vein empties partly into the right branch of the small portal vein of the fetus and partly directly into the vena cava through the ductus venosus (ductus Arantii). When the placental circulation is interrupted by birth, both the umbilical vein and the ductus venosus become obliterated, and the digestive activity of the intestine causes the portal vein to dilate and assume its rôle as the chief afferent hepatic vessel. The umbilical vein is transformed into the round ligament and the ductus venosus into the ligament of the ductus venosus.

THE PANCREAS.

The *pancreas* (Figs. 392 to 394 and 431) is a flat, elongated, lobulated gland, resembling in general appearance and structure the oral salivary glands, and is placed transversely in front of the upper portion of the lumbar vertebral column upon the posterior abdominal wall. It is usually of a grayish-white color in the cadaver and is of rather soft consistence. Three portions, which are not sharply demarcated, may be recognized, namely, the head, the body, and the tail. The head of the pancreas lies in the horseshoe coil of the duodenum, and is the broadest portion of the gland. It almost completely fills the space within the duodenal coil and a special hook-like process, *uncinate process* (*pancreas Winslowii*), curved toward the left and posteriorly, almost surrounds the superior mesenteric vessels (or the portal vein), which are situated in a trough-like depression, the *pancreatic notch*, upon the posterior surface of the gland.

The *body* is smaller than the head, and the *tail*, which is not clearly marked off from the body, is the pointed left end of the organ and extends to the hilus of the spleen. Three pancreatic surfaces may be recognized, the *inferior* one being sharply defined only in the body of the viscus, and not in all cases even in that situation. The two chief surfaces, the *anterior* and the *posterior*, are broad, while the inconstant inferior one is very narrow. The intervening and markedly rounded margins are designated as superior, anterior, and posterior. The anterior and inferior

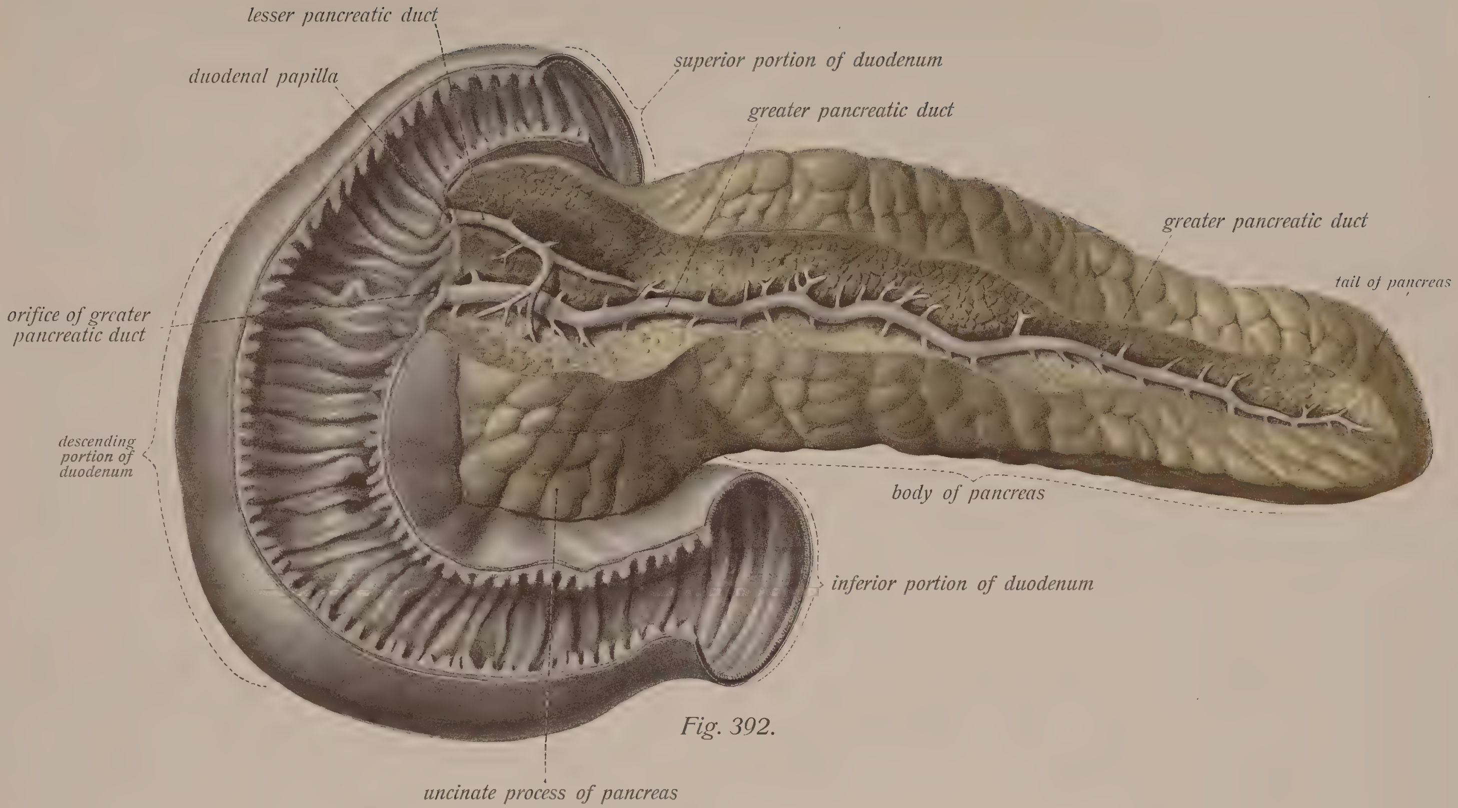

lesser pancreatic duct
duodenal papilla
superior portion of duodenum
greater pancreatic duct
greater pancreatic duct
tail of pancreas
orifice of greater pancreatic duct
descending portion of duodenum
body of pancreas
inferior portion of duodenum
uncinate process of pancreas

Fig. 392.

surfaces are invested by peritoneum from the bursa omentalis; the posterior surface is uncovered by peritoneum and is in contact with the posterior abdominal wall throughout its entire length. At the head of the pancreas, the lower portion of the anterior surface and the uncinate process are also without a peritoneal covering (or without an independent investment) (see page 77).

The anterior surface is curved in the first portion of the body, being markedly convex in the transverse direction, in correspondence with the projection of the vertebral column and the aorta, and the left portion of the organ is distinctly concave as a result of its adaptation to the convex posterior portion of the stomach. In the sagittal direction the same surface is also slightly concave for the same reason, and consequently approaches, although it does not quite attain, a saddle-shaped form. The lower surface and the anterior margin also exhibit a corresponding S-shaped curve. The most marked projection at the left margin of the convexity of the anterior surface corresponds approximately to the concave lesser curvature of the stomach and is called the *tuber omentale* (Fig. 394). The splenic vessels pursue a slightly tortuous course along the superior margin of the gland and frequently produce a groove upon it in this situation.

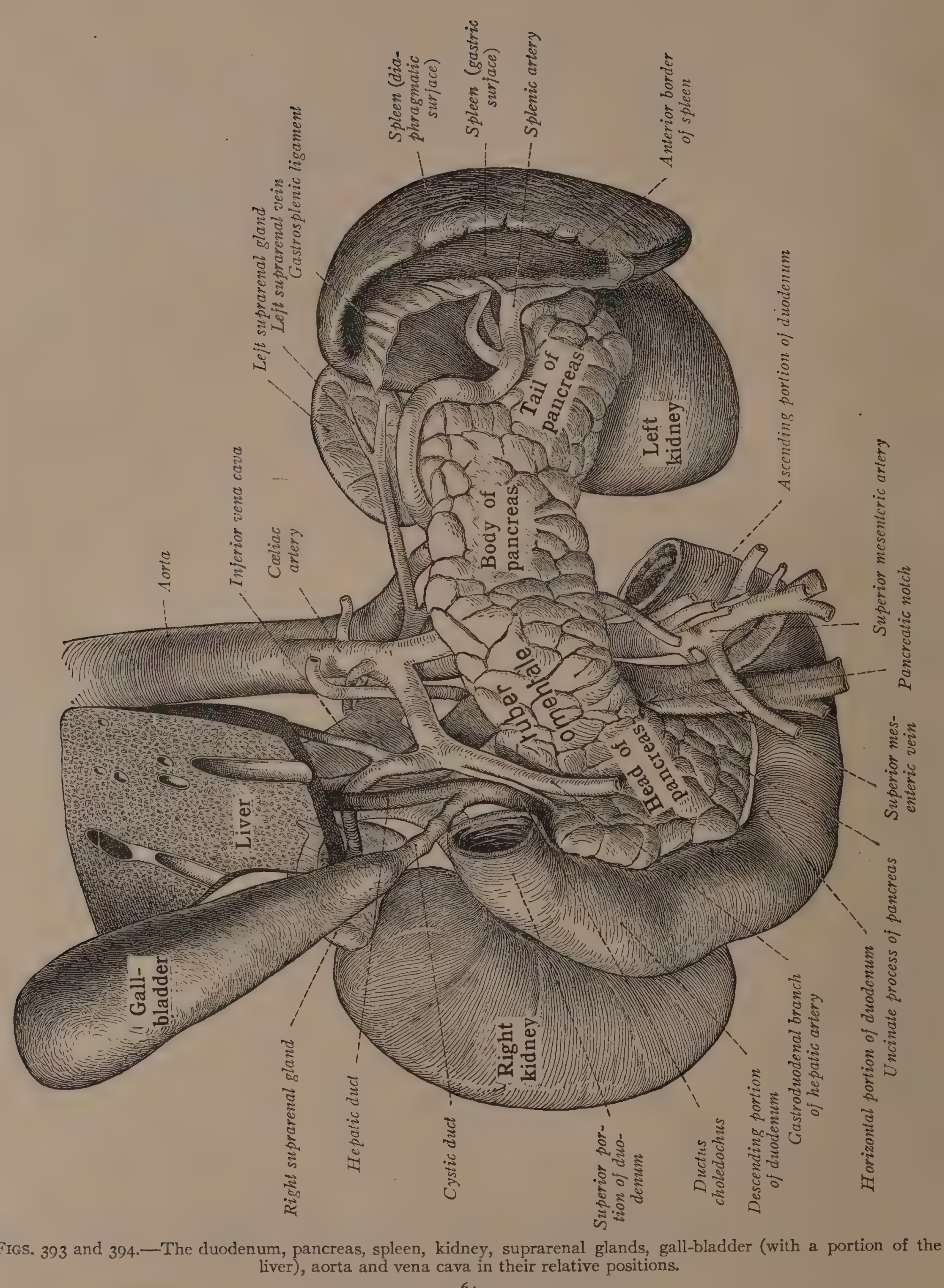
The pancreas is situated in the epigastric region and the tail extends into the left hypochondriac region. It lies in front of the first and second lumbar vertebræ, and the head is to the right of the median line and about two-thirds of the body are to the left.

Its long axis is practically transverse, although its left end is directed slightly upward, and it is in relation with the following viscera (Fig. 413): the duodenum* (head of the pancreas), the posterior surface of the stomach (from which it is separated by the bursa omentalis), the spleen (tip of the tail of the pancreas), the left kidney (tail of the pancreas), the gastrocolic ligament or the transverse colon itself (inferior surface of pancreas), the abdominal aorta,† the inferior vena cava (which lies between the pancreas and the vertebral column), and the portal vein (which arises behind the head of the pancreas). The splenic vessels run along the upper margin of the body and tail of the pancreas, and the pancreatic notch transmits the superior mesenteric vessels, the upward prolongation of the notch lodging the portal vein. Since the pancreas is covered by the peritoneum of the bursa omentalis it becomes visible only after the removal or displacement of the stomach, although the tuber omentale may occasionally be seen through the lesser omentum. The organ is from 9 to 12 cm. long; its greatest breadth is 5 cm. and its thickness is about 1 cm., although in certain situations it is considerably thinner. The *pancreatic duct* (*duct of Wirsung*) (Fig. 392) traverses the entire length of the organ from the head to the tail, gradually becoming larger as it receives the numerous branches which open into it at an acute angle.‡ It is placed nearer to the anterior than to the posterior surface. The head of the pancreas almost always contains a second duct, the *accessory pancreatic duct* (*duct of Santorini*), the relations of which are very variable. It usually opens by a separate orifice into the descending portion of the duodenum (see page 50), but is always connected with the main duct by a transverse branch. More rarely it empties directly into the main duct or it may be entirely absent. It is always

* The borders of the superior and descending portions of the duodenum overlap the pancreas, while the upper border of the inferior portion is frequently concealed by the uncinate process.

† The portion of the abdominal aorta behind the pancreas is that which is situated between the origin of the cœliac artery and that of the superior mesenteric artery.

‡ The ramifications of the pancreatic duct resemble the shape of a poplar tree.



FIGS. 393 and 394.—The duodenum, pancreas, spleen, kidney, suprarenal glands, gall-bladder (with a portion of the liver), aorta and vena cava in their relative positions.

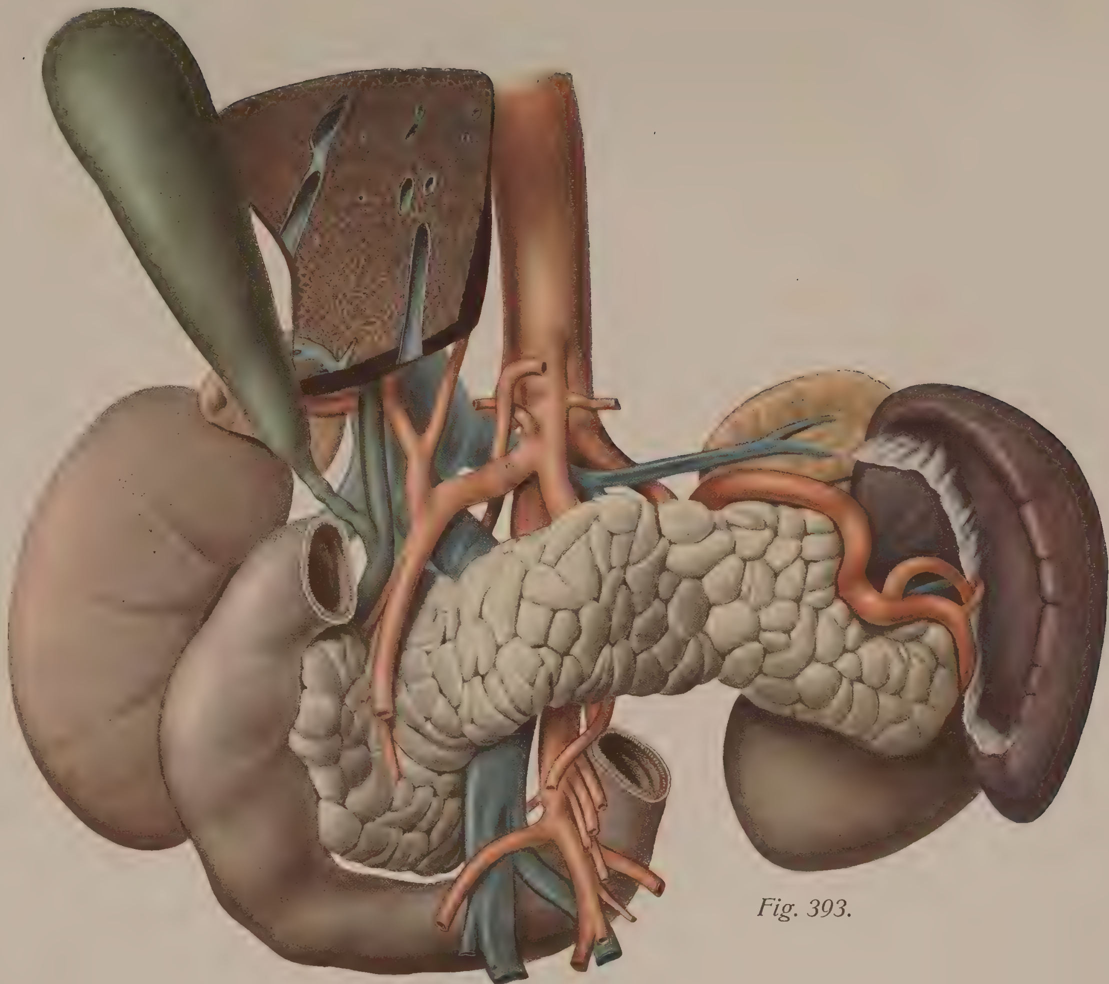


Fig. 393.

situated in the upper portion of the head of the pancreas and its presence is explained by the development of the organ.

The arteries of the head of the pancreas come from the superior and inferior pancreatico-duodenal branches of the hepatic and superior mesenteric arteries respectively; those for the body and tail are the pancreatic branches of the splenic artery. The return blood passes into the portal through the splenic and superior mesenteric veins. The lymphatic vessels go to the cœliac glands and the cisterna chyli, and the nerves come from the cœliac ganglion of the sympathetic and also from the pneumogastric.

The pancreas is formed at about the same time as the liver and arises in a similar manner from that portion of the primitive intestinal tube which subsequently becomes the duodenum. It is first indicated by a double or really threefold protrusion, a single dorsal and a paired ventral one which is intimately connected with the hepatic diverticulum. The dorsal protrusion forms the greater portion of the pancreas, the ventral a much smaller part, although both fuse so completely that the duct of the smaller ventral components becomes the greater pancreatic duct and receives the secretion from the originally larger dorsal pancreas, while the secretory duct of the latter, the accessory pancreatic duct, remains small or even completely disappears (see page 63).

THE SPLEEN (LIEN).

The *spleen* (Figs. 393, 394, 396 to 398, 405, 406, 413, and 416) is topographically and also physiologically related to the digestive tract, although in other respects it must be classified as a part of the vascular system. It is a vascular gland whose structure is related to that of a lymphatic node.

In form it is a somewhat flattened organ, shaped like a halved ellipsoid, and possesses a convex and a subdivided concave surface. The convex surface is directed outward, upward, and backward, and as it fills the postero-inferior portion of the left cupola of the diaphragm it is termed the *diaphragmatic* surface. The other surface is directed inward, and its anterior and inferior portion is concave until it encounters a longitudinal slightly elevated ridge, the *hilus*, which presents depressions for the entrance of vessels, and also receives the insertion of the gastrosplenic ligament (see page 76). The elevation of the hilus disappears toward the superior and inferior margins of the organ, and the adjacent concavities being made by the contiguous viscera, are, like those of the liver, distinct only when the organ is *in situ*. Owing to the marked softness of the splenic tissue they soon disappear upon the removal of the viscus.

The hilus divides the inner surface of the spleen into an antero-superior portion and a postero-inferior portion (Figs. 397 and 398), the former being designated as the gastric and the latter as the renal surface. The gastric surface is in contact with the fundus of the stomach. The renal surface is subdivided into two slightly defined concave impressions, a larger and markedly concave upper one for the upper pole of the left kidney, and a smaller and flatter lower one for the tip of the tail of the pancreas and the splenic flexure of the colon. There may also be recognized a superior extremity of the spleen, turned upward and inward, and an inferior extremity which is directed downward and outward. The rounded posterior border is usually smooth, while the anterior one is almost always sharper and notched (Figs. 396 and 397).

The spleen is the reddest of all the abdominal viscera, its red color, however, always presenting a slightly bluish tinge. Its surface is smooth and, with the exception of the narrow hilus, completely invested by peritoneum. Small depressions or foldings of the surface are occasionally observed. The splenic tissue is exceedingly soft and brittle, and is held together by a firm capsule, the *tunica albuginea*, from which *splenic trabeculæ* proceed through the substance of the organ, the larger ones and their chief ramifications being visible to the naked eye in a cross-section.

FIG. 395.—The gall-bladder and cystic duct, split open lengthwise.
FIG. 396.—The spleen from the diaphragmatic surface.
FIG. 397.—The spleen, seen from the hilus surface.

Such a section also reveals lymphatic nodules in the spleen, small grayish-red spherical or elliptical areas within the dark bluish-red splenic pulp.

The spleen is loosely attached to the stomach by the gastrosplenic ligament, and to the diaphragm by the phrenicocolic ligament (see page 76). It is in contact with the following structures: the stomach (gastric surface), the diaphragm (diaphragmatic surface), the upper pole of the left kidney and the suprarenal body (renal surface), the tail of the pancreas and the splenic flexure of the colon. It is situated in the left hypochondriac region and is entirely concealed behind the costal cartilages and the lower ribs. Its longitudinal axis passes obliquely from behind forward and from above downward, and is approximately parallel to the course of the lower ribs, usually to that of the tenth, and its transverse axis runs between the ninth and the eleventh ribs. The upper end of the posterior margin corresponds almost to the angle of the ninth rib; the lower end of the anterior margin, which lies upon the fundus of the stomach and is the most anterior portion of the viscus, extends only a trifle in front of the posterior axillary line.

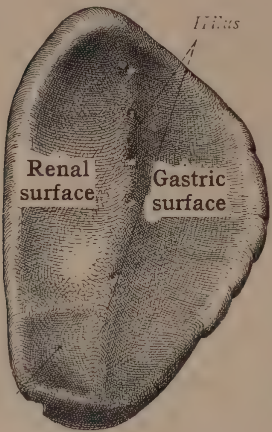


FIG. 398.—The contact surfaces of the spleen.

The spleen is 12 or 13 cm. long (in its greatest dimension), 7 or 8 cm. wide, and 3 cm. thick, becoming considerably thinner toward its borders.

The splenic artery arises from the cœliac artery and divides in front of the hilus into numerous branches, some of which pass to the stomach (see page 47). The splenic vein holds a relation to the hilus of the spleen similar to that of the artery, and is one of the two roots of the portal vein (see page 62). The nerves of the spleen are chiefly sympathetic.

The origin of the human spleen is as yet not definitely known. From investigations on the lower vertebrates, however, it is clear that it does not arise from the endoderm, like the intestine, liver, and pancreas, but from the mesoderm [making its first appearance as a localized thickening of the left layer of the mesogastrium.—ED.].

Accessory spleens are rather frequent. Their size varies, usually being that of a hazelnut, and while they are most frequently situated in the immediate vicinity of the spleen, especially in the gastrosplenic ligament, they are sometimes also found in the great omentum near the pancreas and even in the root of the mesentery. Of rarer occurrence is the subdivision of the spleen into numerous small isolated masses, each of which surrounds a branch of the splenic artery; deep grooves indicating such a subdivision are somewhat more common.

THE PERITONEUM.

The *peritoneum* is one of the serous membranes (see page 19) and forms the largest serous sac in the human body. This serous sac is situated in the abdominal cavity and partly also in the pelvic cavity.

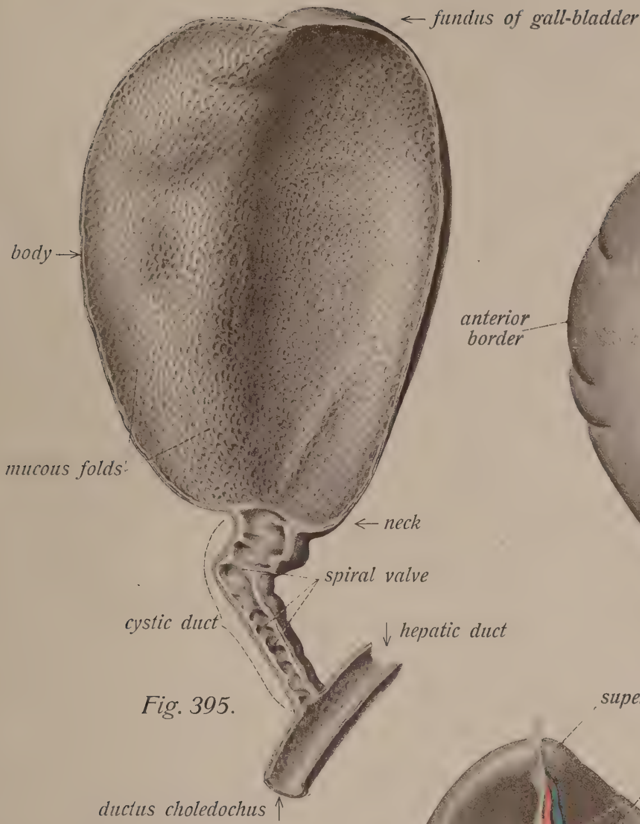


Fig. 395.

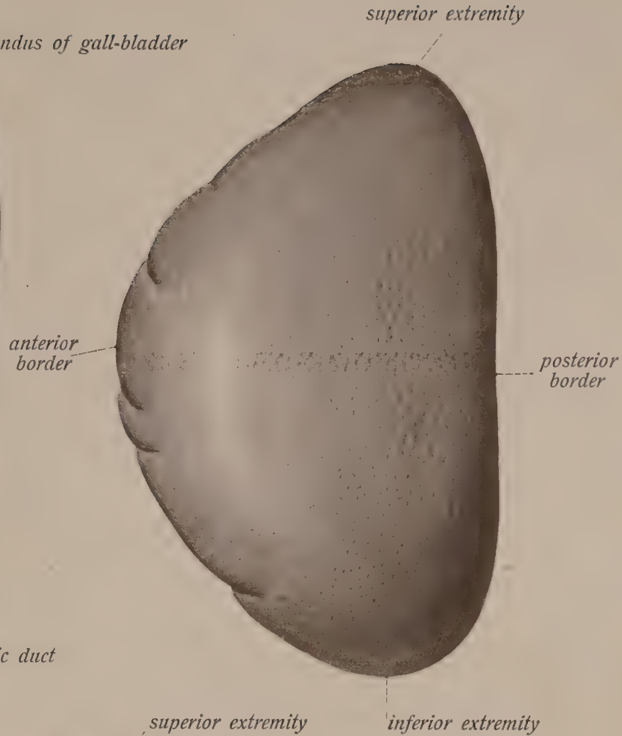


Fig. 396.

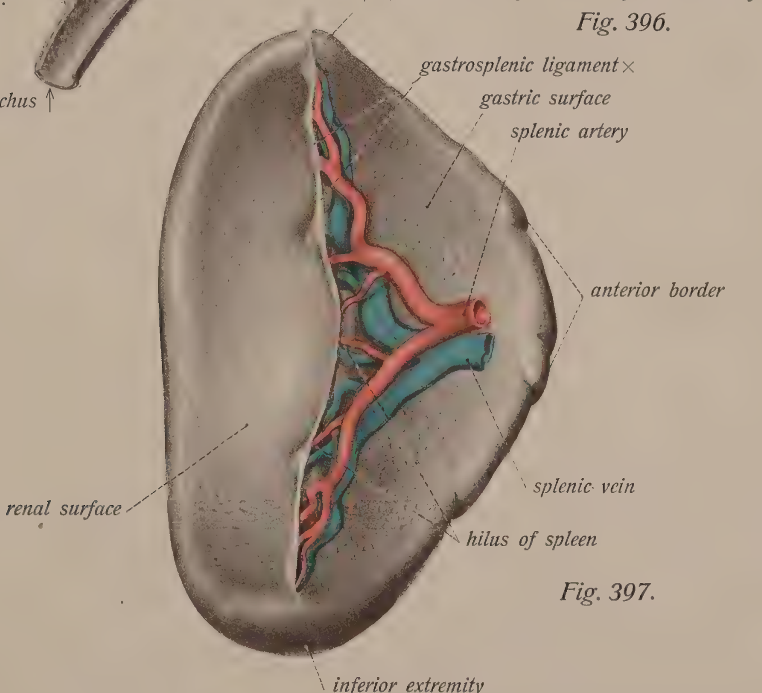


Fig. 397.

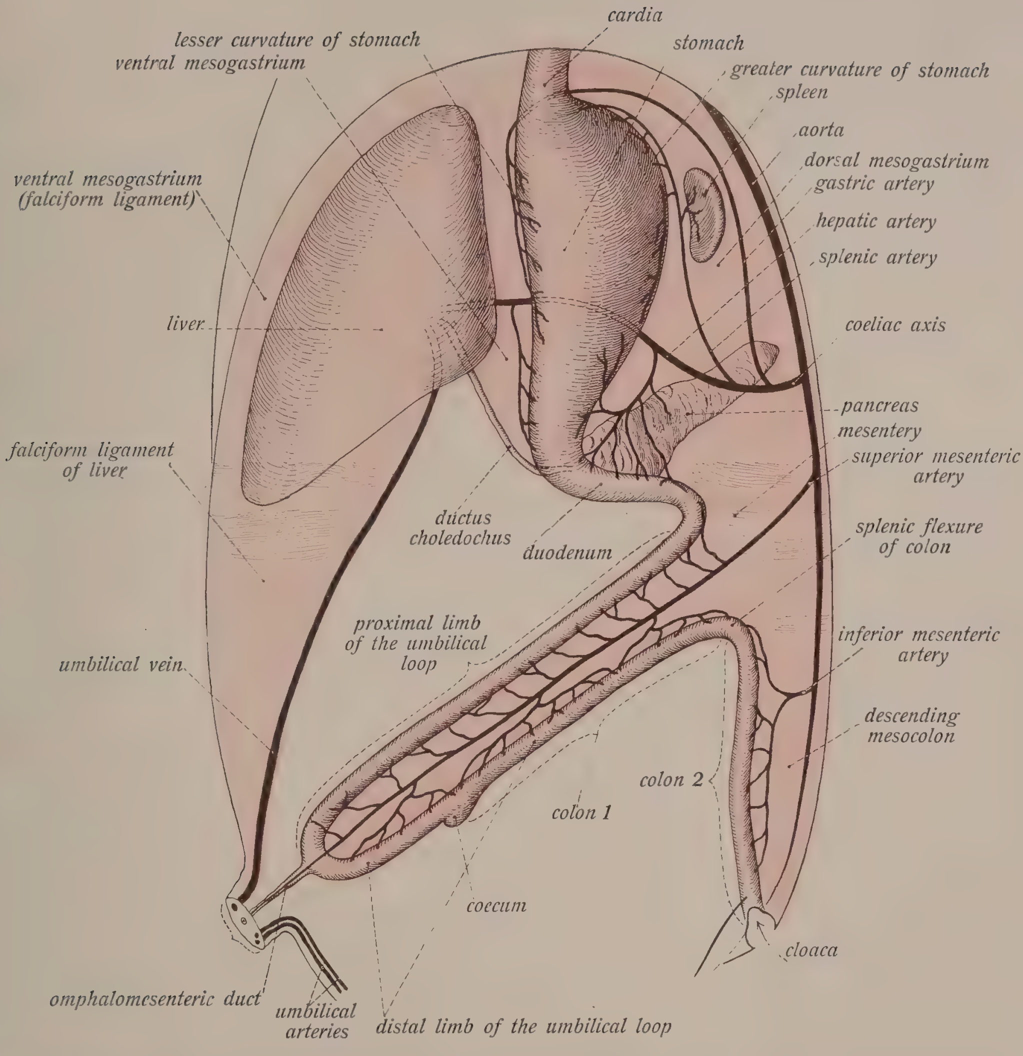


Fig. 399. First stage of the development of the intestinal canal and the peritoneum, seen for the side (diagrammatic). From colon 1 the ascending and transverse colon will be formed and from colon 2 the descending and sigmoid colons and the rectum.

The abdominal cavity is a large elongated space situated in the lower portion of the trunk, and is separated from the thoracic cavity by the diaphragm. It is bounded throughout the greater portion of its extent by the abdominal muscles. The roof of the abdominal cavity is formed by the diaphragm (see Vol. I, page 164) and its configuration accurately corresponds to that of the inferior surface of this muscle; only the posterior wall having a partly bony boundary, the lumbar vertebral column. The remainder of this wall is formed by muscles (the crura of the diaphragm, the psoas, the quadratus lumborum, and behind these the muscles of the back), the roof is formed by and accurately conforms to the inferior surface of the diaphragm; the lateral walls are formed by the flat abdominal muscles, and these together with the recti also constitute the anterior wall. The floor of the cavity is partly formed by the alæ of the iliac bones together with the iliac muscles; these also belong to the posterior and lateral boundaries. The abdominal cavity communicates directly with the pelvic cavity by means of the superior aperture of the pelvis, this latter cavity being bounded by the bones and ligaments of the true pelvis (see Vol. I, page 128) and by the muscles which arise from their internal surfaces (the obturator internus and the piriformis), while its floor is formed by the muscles and fasciæ of the pelvic outlet (see page 156, *et seq.*).

THE DEVELOPMENT OF THE PERITONEUM.

In the adult the peritoneum has a complicated arrangement which can be explained only by a reference to the development of the membrane in the embryo. For this reason a very brief sketch of its development, which is intimately connected with that of the intestinal canal (see page 56), will be given.

When the intestinal canal is still a straight tube and the future stomach is indicated simply by a fusiform dilatation the common mesentery of the entire gut passes from the posterior abdominal wall and the aorta to the primitive gut as a narrow lamina which is situated approximately in the sagittal plane. That portion of the mesentery which is in connection with the future stomach is designated the *mesogastrium;* it passes from the aorta to what will later be the greater curvature of the stomach, and from the lesser curvature to the anterior abdominal wall, extending upward to the diaphragm and downward to the umbilical vein.

The same arrangement of the mesentery obtains at the time of development of the primitive umbilical loop (see page 57, Fig. 399). The outgrowth for the liver grows into the ventral mesogastrium, that portion of the mesogastrium which extends between the stomach and the anterior abdominal wall, while the outgrowths for the pancreas extend into the dorsal mesogastrium, in which the spleen also develops. This mesenterial area is supplied by the cœliac artery. The larger mesenteric area produced by the development of the umbilical loop is nourished by the superior mesenteric artery, while the lower portion, the almost unaltered mesentery of the terminal portion of the intestinal tube, derives its blood-supply from the inferior mesenteric artery.

As a result of the previously described rotation of the stomach, the posterior mesogastrium attached to the greater curvature is markedly increased in length, and the side previously directed toward the left now takes up its position in front of the posterior abdominal wall, while that originally directed toward the right now looks toward the posterior surface of the stomach (Fig. 400), so that the mesogastrium is now in the frontal instead of in the sagittal plane and encloses the pancreas between its two layers. It has the shape of a curved lamina which forms a pocket, closed toward the left and open toward the right, the first indication of the *bursa omentalis* (*lesser sac* of the peritoneum). This is soon followed by the first trace of the second important structure derived from the mesogastrium, the *great omentum*, which originates as a diverticulum of the dorsal mesogastrium immediately before its attachment to the greater curvature of the

stomach, the diverticulum gradually increasing in length and becoming flattened from before backward to form the two layers of the great omentum. The liver by its growth gradually fills out the space between the two layers of the ventral mesogastrium with the exception of

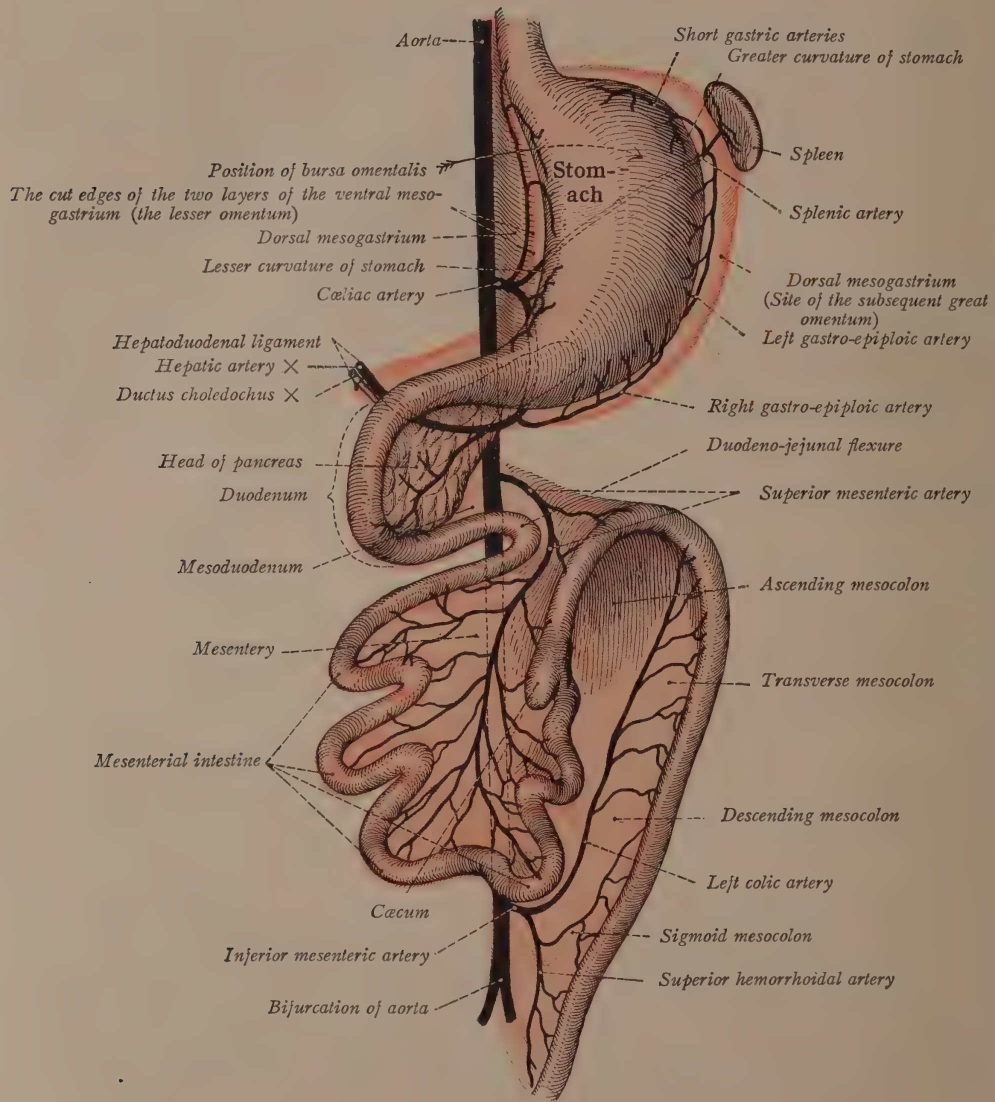


FIG. 400.—Second stage of the development of the intestinal canal and peritoneum, seen from in front (diagrammatic). The liver has been removed and the two layers of the ventral mesogastrium (lesser omentum) have been cut. The vessels are represented in black and the peritoneum in the reddish tint.

a portion which later becomes the falciform ligament of the liver, and the portion which extends between the lesser curvature of the stomach and the liver, forming the *lesser omentum*. At the same time the liver gradually takes up its position more upon the right side of the body.

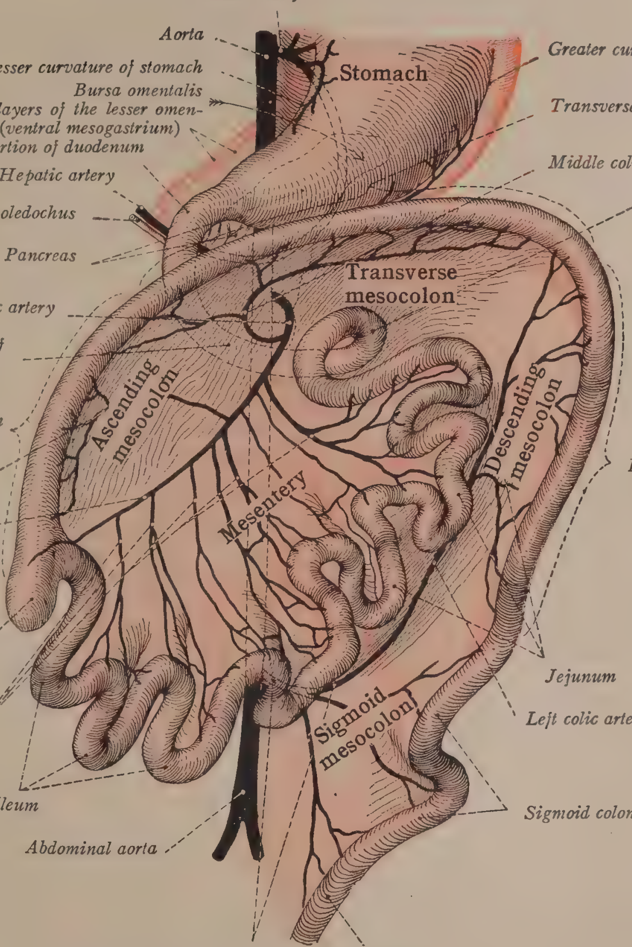


FIG. 401.—Third stage of the development of the intestinal canal and peritoneum, seen from in front (diagrammatic). The mode of preparation is the same as in Fig. 400.

Even after the development of the flexures of the colon the lower portion of the common mesentery exhibits the same relation as before. The mesentery is attached to the entire length

of that surface of the gut which was originally directed toward the aorta, but as a result of the increasing convolution of the intestine it is no longer a flat plate, but presents manifold curvatures, and the mesentery of the large intestine overlies that of the small intestine (especially that of the duodenum).

The subsequent changes consist essentially in the formation of adhesions between certain visceral portions of the peritoneum and the contiguous parietal layer. By these adhesions the affected peritoneal laminæ become obliterated and peritoneal surfaces which were originally

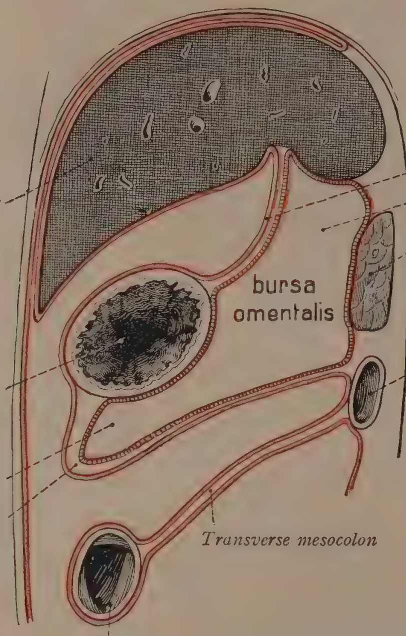


FIG. 402.—Diagram of the formation of the great omentum. Median section. The peritoneum is red and the walls of the bursa omentalis are shaded.

visceral become parietal as a result of secondary changes, this process taking place in different regions of the embryonic peritoneum and producing in some regions very extensive changes. The portion of the posterior mesogastrium which lies parallel to the posterior abdominal wall becomes adherent to the subjacent parietal peritoneum and also to the pancreas which is included between its two layers; and as a result of this adhesion the surface of that portion of the mesentery which is directed toward the stomach and the peritoneum investing the anterior surface of the pancreas, *i. e.*, the posterior wall of the subsequent bursa omentalis, secondarily becomes a parietal layer. In a similar manner the lower portion of the mesogastrium, the mesoduodenum, together with the head of the pancreas, becomes adherent to the posterior abdominal walls.

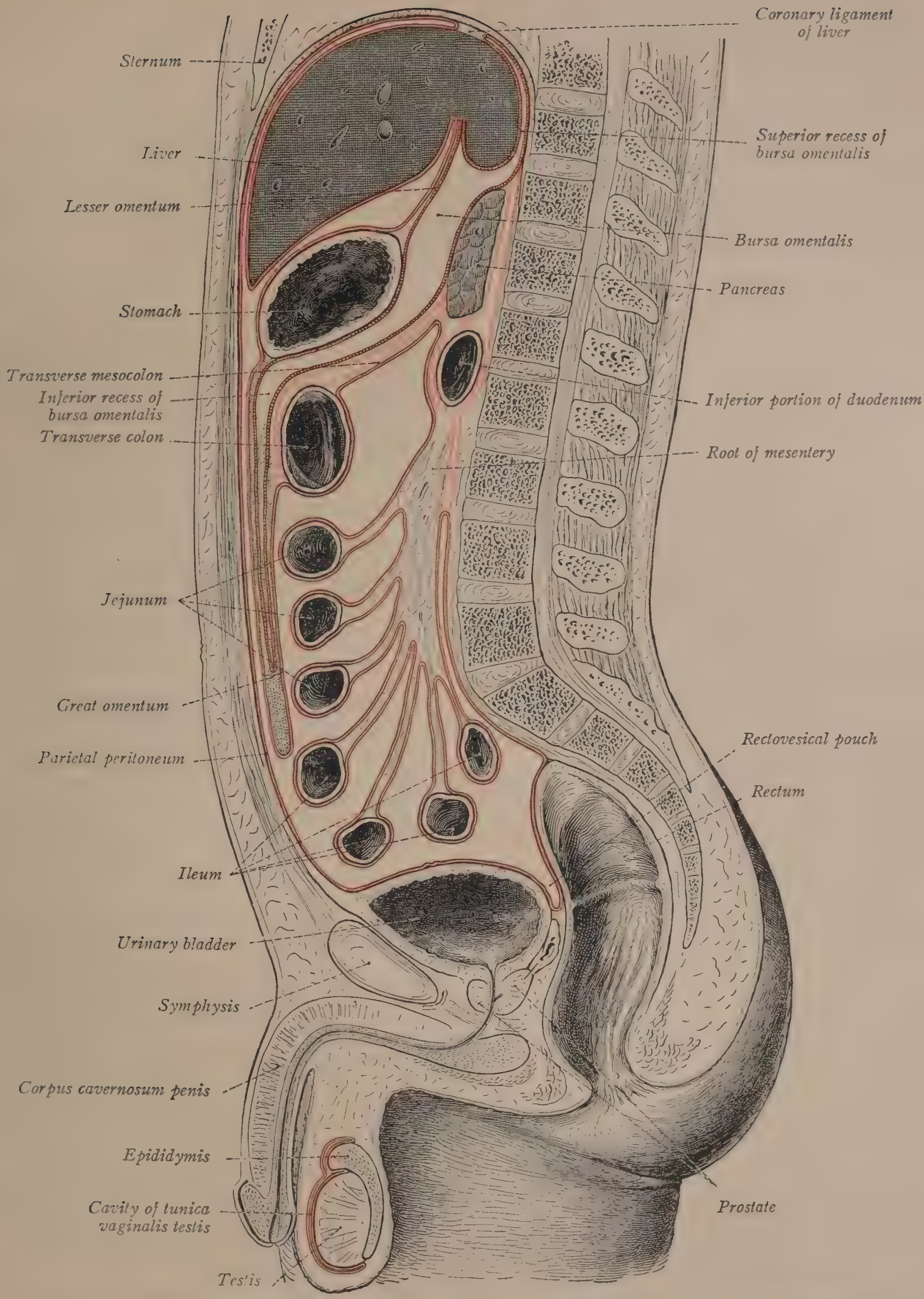


FIG. 403.—Diagram of the arrangement of the peritoneum in the male as seen in a median sagittal section. The peritoneum is represented in red; that of the bursa omentalis being shaded; the broken red lines and the black stippling represent respectively portions of peritoneum and cavities which have disappeared.

The same changes occur throughout a large portion of the colon. The ascending and descending colons originally possess an independent mesentery like the transverse and sigmoid colons, but between the fourth and fifth months of embryonic life first the ascending and then the descending mesocolon becomes adherent to the primary parietal peritoneum in the region of

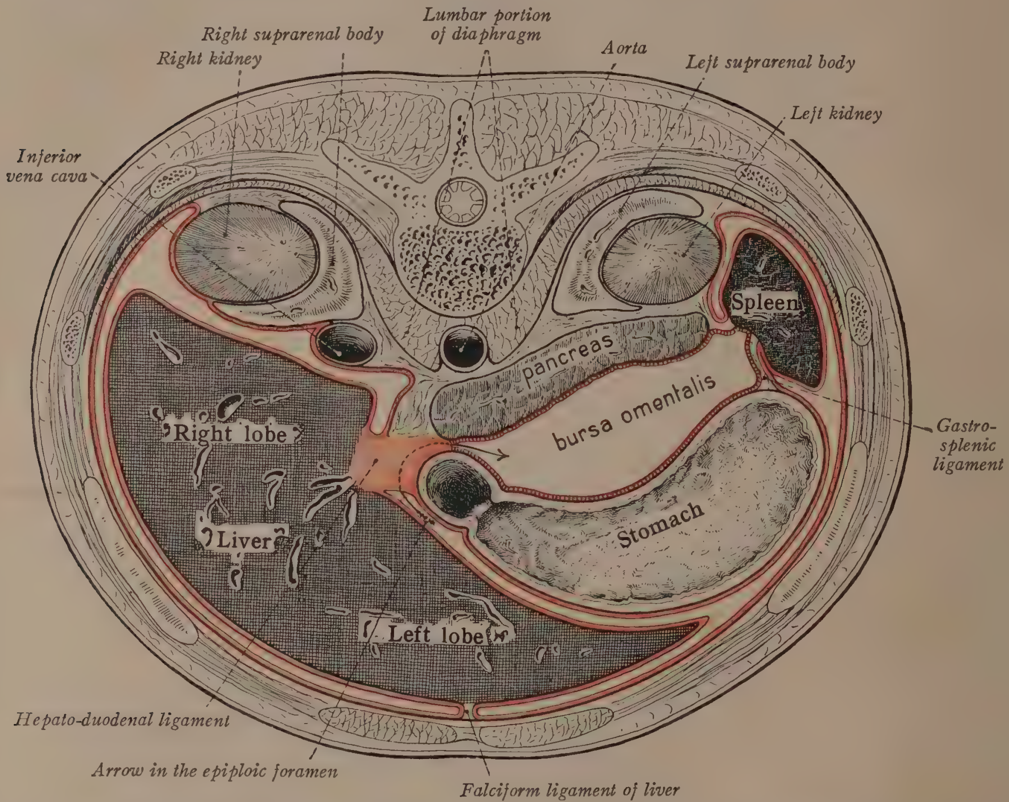


FIG. 404.—Diagram of the arrangement of the peritoneum seen in transverse section passing through the bursa omentalis. The peritoneum is represented in red and that of the bursa omentalis is also shaded. The portion of the parietal layer which has disappeared as the result of pancreas coming into relation with the posterior abdominal wall is not represented.

the kidneys, the result being the fixation of the ascending and descending colons to the posterior abdominal wall.* As a result of these adhesions further changes occur. The ascending mesocolon, which is converted secondarily into parietal peritoneum, also becomes adherent to the anterior surface of the duodenum and thus causes it to lose a considerable portion of its independent mesentery, and the primary line of attachment of the mesentery to the aorta is thus

* The lamina mesenterii propria of the ascending and descending mesocolon is, however, retained.

separated into two portions, one for the mesenterial intestine, the root of the mesentery (see page 76), and a transverse one for the transverse mesocolon (Fig. 401).

The posterior layer of the great omentum finally becomes adherent to the upper layer of the transverse mesocolon (Fig. 403), so that the latter structure acquires secondary relations with the great omentum, and, at the same time, the entire upper surface of the transverse mesocolon becomes the posterior (inferior) wall of the bursa omentalis. With the downward growth of the great omentum from the greater curvature of the stomach, a process of the bursa omentalis, the *inferior recess* (Fig. 402), extends into the great omentum, so that from this time on both the secondary transverse mesocolon and the great omentum consist of four layers, although after birth, and to a varying degree, the layers of the great omentum become adherent with each other.

THE PERITONEUM IN ADULT LIFE.

The adult *peritoneum* (Figs. 403 to 417) is a closed sac consisting of two layers separated by a capillary space. One layer lines the inner surface of the abdominal wall and is known as the *parietal peritoneum*, while the other invests the viscera in the abdominal cavity and is termed the *visceral peritoneum*.* The capillary space between the two layers is called the *peritoneal cavity* and contains an exceedingly small quantity of fluid. The visceral layer includes not only the serous coverings of the actual viscera (stomach, liver, intestines, pancreas), but also the peritoneum which invests the laminæ and ligaments passing from the abdominal wall to the viscera. These structures frequently pass transversely across the abdominal cavity; they contain the vessels and nerves for the various viscera and are known as the *laminæ mesenterii propriæ* (Fig. 322), and together with their peritoneal coverings they are known as *mesenteries*. As a result of its epithelial covering the surface of the peritoneum is smooth and glistening and the surfaces of the invested viscera consequently exhibit the same characteristics.

In the male the peritoneal sac is closed upon all sides; in the female it communicates with the genital tract through the abdominal orifice of the Fallopian tube.† The parietal layer of the peritoneum is not in immediate contact with the posterior abdominal wall, but is usually separated from it by the transversalis fascia (see Vol. I, page 163), and it is generally stronger than the visceral layer which is firmly and intimately adherent to the majority of the viscera. The serous investment of the viscera is designated as the *serous coat*, and beneath this there is usually a layer of loose connective tissue, known as the *subserous coat* (see page 20).

The adult peritoneum pursues the following course (Fig. 403): The parietal layer passes upward upon the posterior surface of the anterior abdominal wall and passes thence directly to the under surface of the diaphragm. From there it is reflected to the upper border of the posterior surface of the liver and becomes visceral, this reflection, which extends across almost the entire breadth of the liver, being called the coronary ligament of the liver. The simplicity of this condition is modified by the falciform (suspensory) ligament of the liver (Figs. 387, 388, and 416) which is a thin peritoneal duplicature, consisting of two layers, which extends from the

* Many portions of the subsequent parietal peritoneum originally belonged to the visceral layer, as has been shown in the preceding outline of the embryology of the peritoneum.

† There is also an apparent interruption of the connective-tissue layer of the peritoneum at the ovary, but the germinal epithelium of the ovary is nothing more or less than modified peritoneal epithelium.

Fig. 405.—The upper portion of the abdominal cavity with the stomach, liver, spleen, and lesser omentum.

The left lobe of the liver is drawn upward and a sound (*) has been passed into the vestibule of the bursa omentalis. The anterior layer of the great omentum, the gastrocolic ligament, has been divided so as to expose the transverse colon.

Fig. 406.—The epiploic foramen and the bursa omentalis.

The entire liver has been drawn upward, the hepatoduodenal ligament drawn toward the left and the stomach drawn upward, after cutting the gastrocolic ligament immediately below the greater curvature, so as to expose the bursa omentalis and the pancreas. A sound has been passed through the epiploic foramen.

Fig. 407.—View of the abdominal viscera from in front, showing the great omentum.

Fig. 408.—View of the abdominal viscera from in front, the great omentum having been drawn upward.

The transverse colon has also been drawn somewhat upward with the omentum.

Fig. 409.—View of the abdominal viscera from in front, the great omentum having been drawn upward and the small intestine displaced toward the right.

A sound has been introduced into the duodeno-jejunal recess.

Fig. 410.—The large intestine *in situ*.

The small intestine from the duodenum to the terminal portion of the ileum has been removed, by cutting its mesentery close to its insertion into the intestine; the great omentum and transverse colon have been drawn upward. A sound has been introduced into the inferior ileocæcal recess.

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posterior surface of the anterior abdominal wall and from the inferior surface of the diaphragm to the superior surface of the liver (Fig. 399). It is narrow at the umbilicus and gradually becomes wider as it approaches the liver, where it is attached to the right of the median line, while its origin from the anterior abdominal wall is situated almost in the middle line. Inferiorly and posteriorly this approximately triangular ligament presents a free border, which passes from the umbilicus to the umbilical notch of the liver, and contains the obliterated umbilical vein, the round ligament of the liver. It is a portion of the ventral mesogastrium. In the anterior portion of the superior surface of the liver its two layers are in immediate contact, but posteriorly they diverge and become continuous with the coronary ligament.

The *coronary ligament* (Figs. 387 and 388) is not as broad as the posterior hepatic surface, since it does not extend to the tip of the right lobe. It is very short throughout, so that the liver is held close against the diaphragm, and consists of two layers which are in contact only in the region of the left lobe of the liver, being separated at the middle of the liver and the right lobe by that portion of the posterior hepatic surface which is uncovered by peritoneum (see page 59, Fig. 388). The somewhat divergent free left and right extremities of the coronary ligament are known as the *left* and *right triangular ligaments;* the former contains the fibrous appendix of the liver (see page 59), and in the latter the previously widely separated layers of the coronary ligament become approximated for a short distance. The right extremity of the right lobe of the liver is surrounded by the visceral layer of the peritoneum, which in this situation has no direct connection with the parietal layer, except through the right triangular ligament.

The anterior layer of the coronary ligament invests the superior surface of the liver and passes over its anterior border to the inferior surface, completely enveloping the right half of the right lobe, and the middle portion and left lobe, extending backward to join the posterior layer of the ligament. From the region of the porta hepatis the peritoneum extends to the lesser curvature of the stomach and to the upper margin of the superior portion of the duodenum as

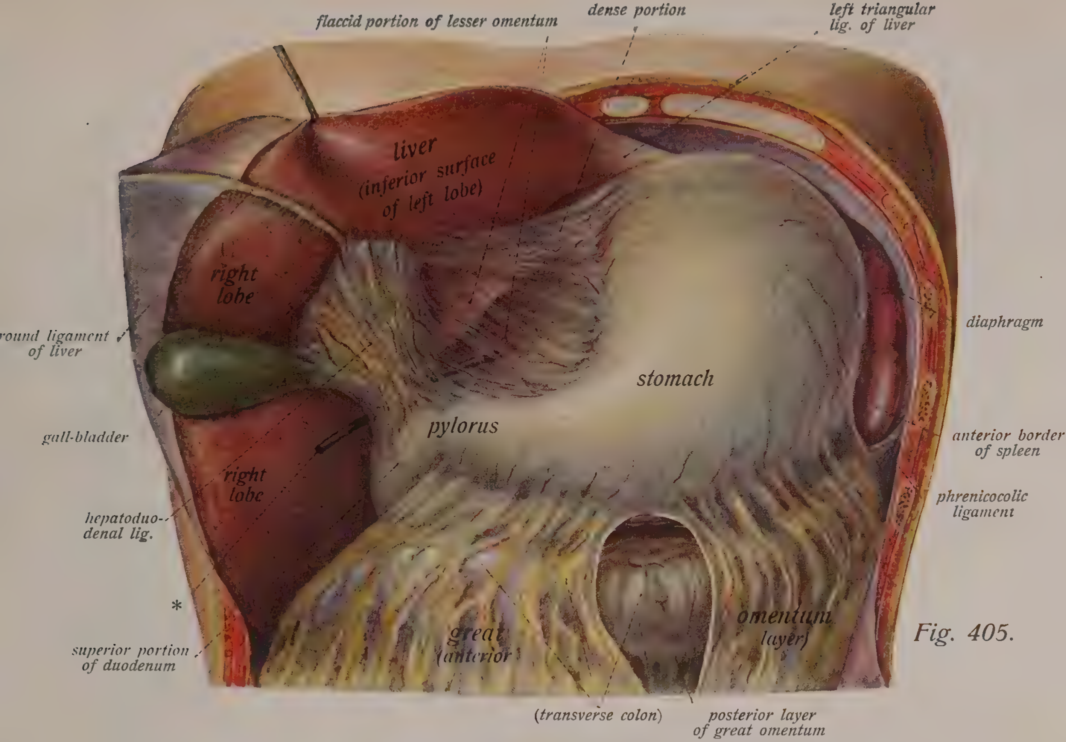


Fig. 405.

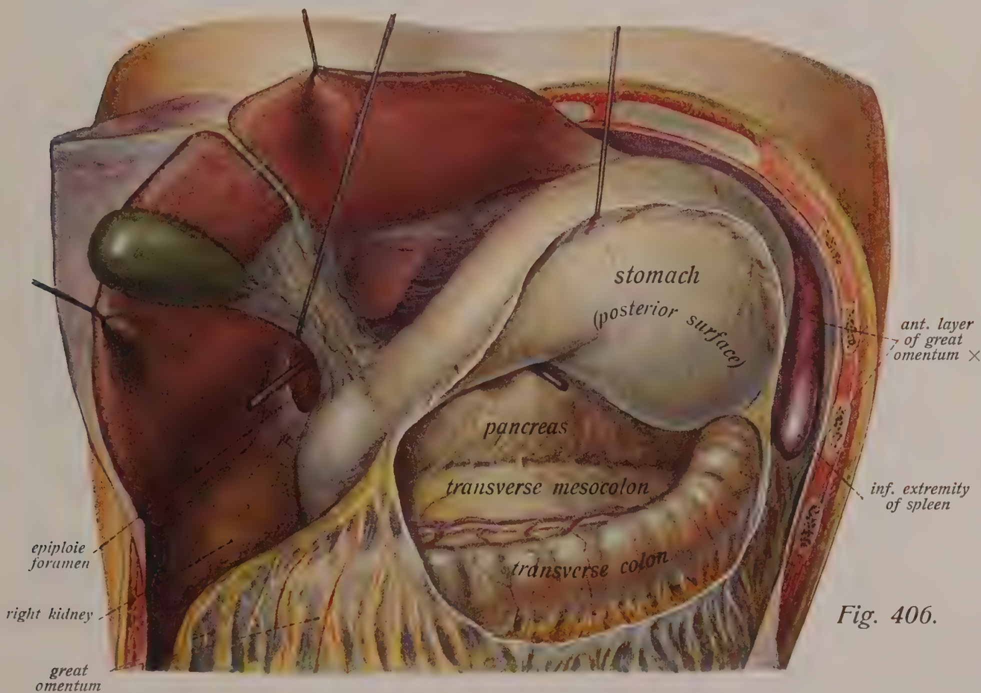


Fig. 406.

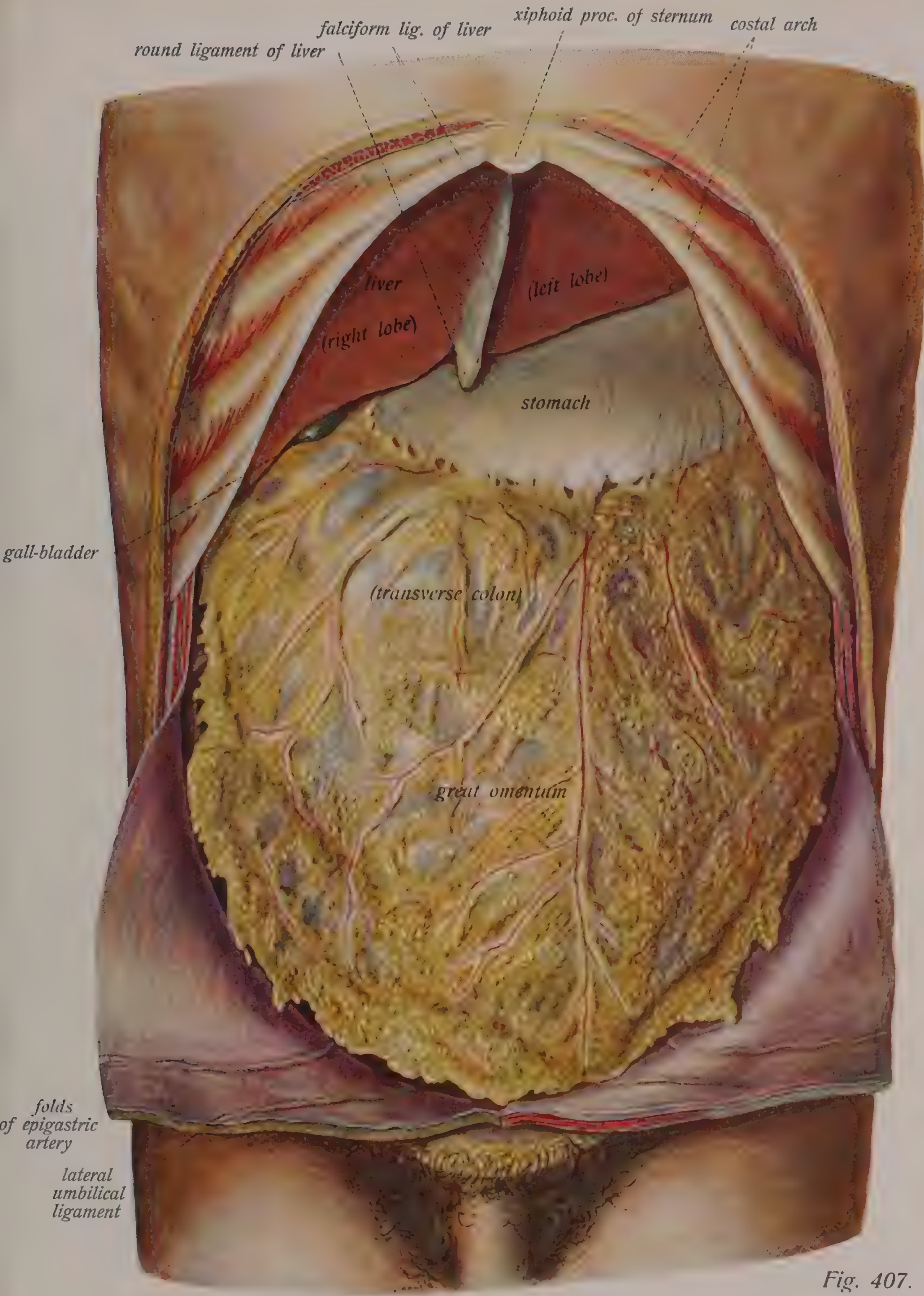

xiphoid proc. of sternum
costal arch
falciform lig. of liver
round ligament of liver
liver
(left lobe)
(right lobe)
stomach
gall-bladder
(transverse colon)
great omentum
folds of epigastric artery
lateral umbilical ligament

Fig. 407.

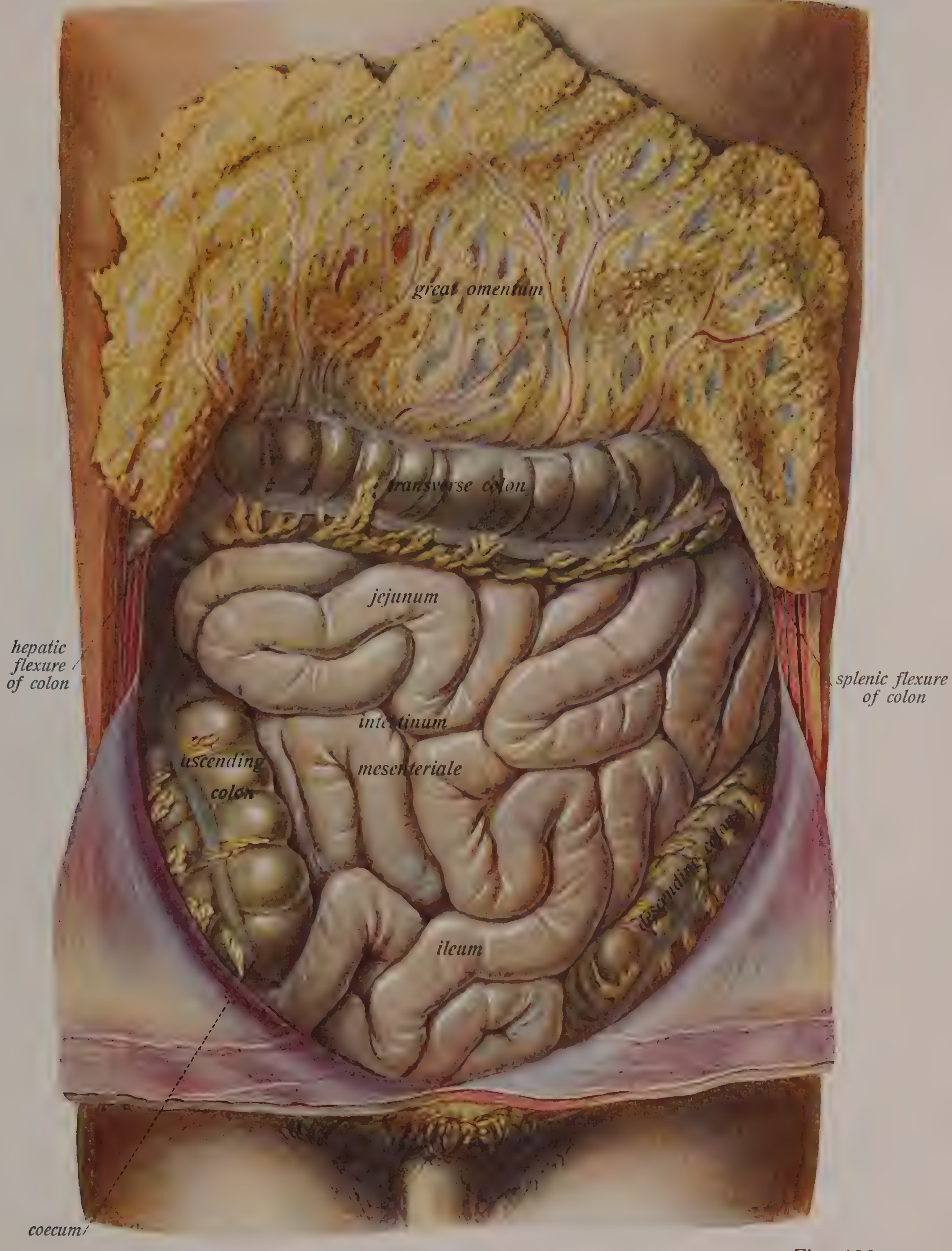
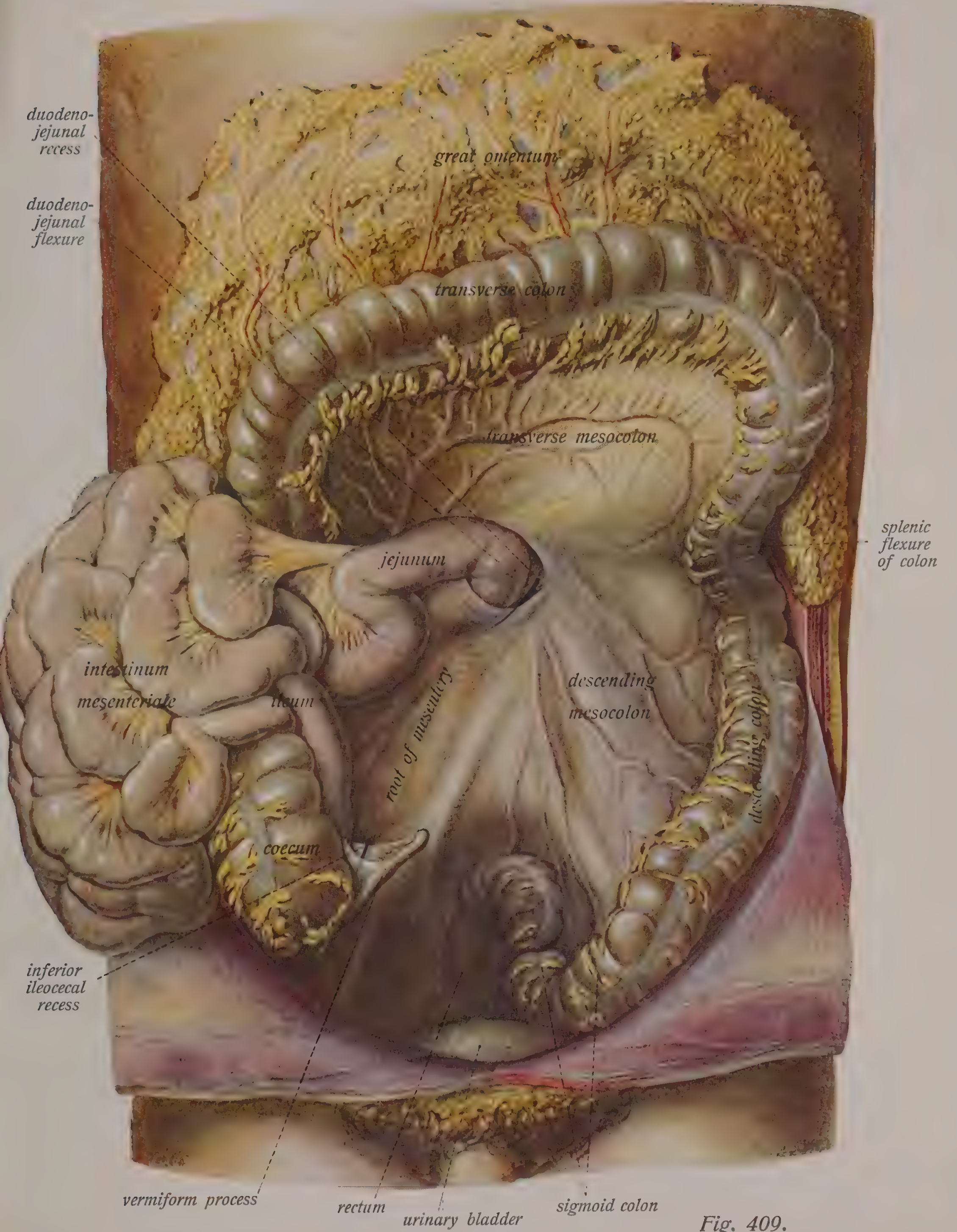

great omentum
transverse colon
jejunum
hepatic flexure of colon
splenic flexure of colon
intestinum
mesenteriale
ascending colon
descending colon
ileum
coecum

Fig. 408.



duodeno-
jejunal
recess
duodeno-
jejunal
flexure
great omentum
transverse colon
transverse mesocolon
splenic
flexure
of colon
jejunum
intestinum
mesenteriale
ileum
root of mesentery
descending
mesocolon
descending colon
coecum
inferior
ileocecal
recess
vermiform process
rectum
urinary bladder
sigmoid colon

Fig. 409.

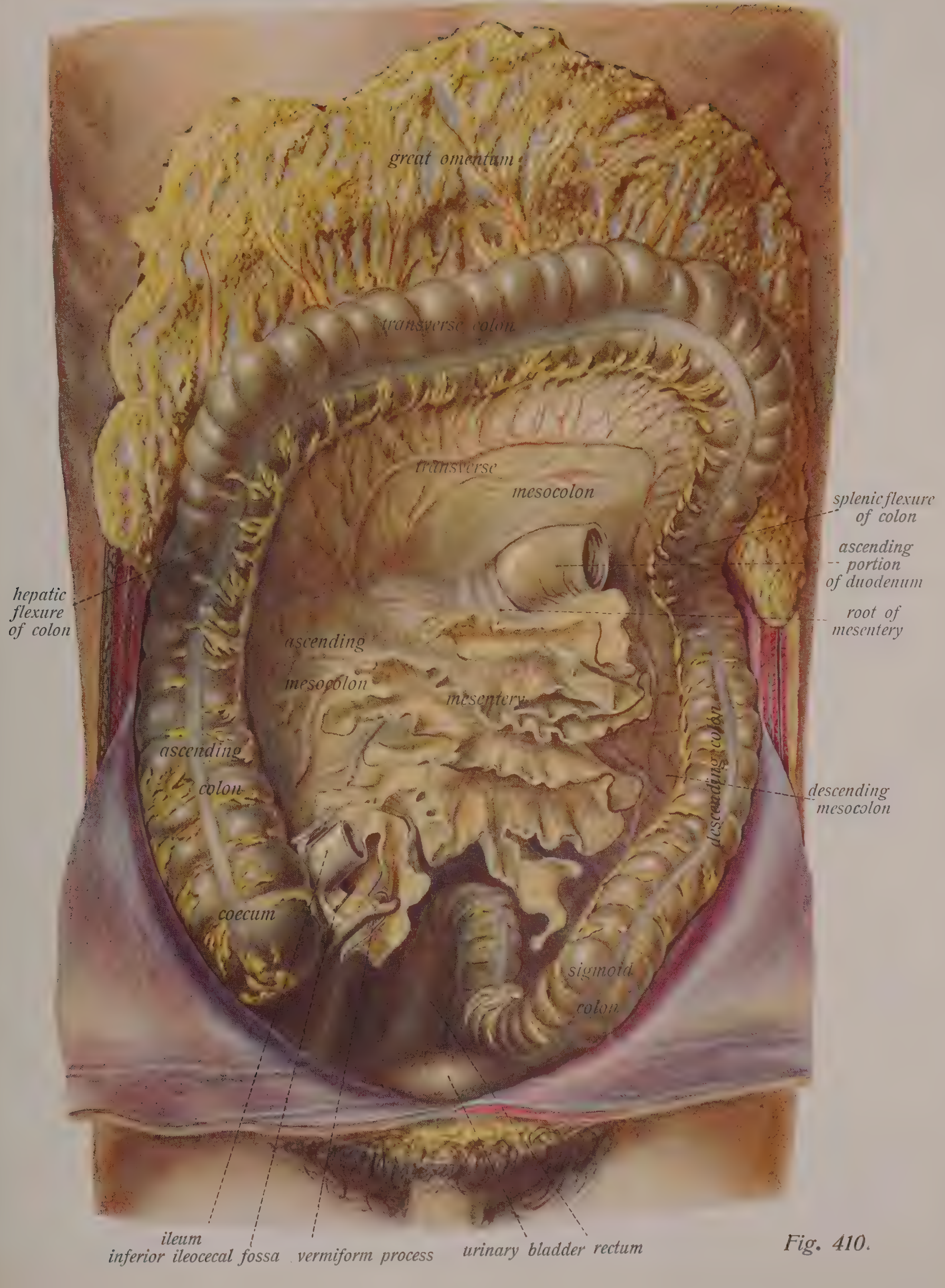

great omentum
transverse colon
transverse
mesocolon
splenic flexure
of colon
ascending
portion
of duodenum
root of
mesentery
hepatic
flexure
of colon
ascending
mesocolon
mesentery
ascending
colon
descending colon
descending
mesocolon
coecum
sigmoid
colon
ileum
inferior ileocecal fossa
vermiform process
urinary bladder
rectum

Fig. 410.

the anterior layer of the *lesser omentum* (Fig. 405), an approximately triangular fold of peritoneum which originates chiefly from the porta hepatis, but also from the neighboring fissure of the ductus venosus and the adjacent portion of the inferior surface of the left lobe. In it there are recognizable two portions which are directly continuous with each other: (1) the *hepatogastric ligament*, which passes from the porta hepatis to the lesser curvature of the stomach and to the abdominal portion of the œsophagus, and (2) the *hepatoduodenal ligament* (Figs. 405 and 406), which forms the right margin of the lesser omentum. The portion of the hepatogastric ligament which passes to the cardia and œsophagus (the dense portion of the lesser omentum) is somewhat denser than that passing to the lesser curvature (the flaccid portion), which is so thin and transparent that the sharp margin of the caudate lobe may be seen through its substance (see page 59, Fig. 405). The hepatoduodenal ligament is still more dense and opaque, since it contains the vessels passing to and from the porta hepatis (see page 58).

To the right and left of the porta hepatis, however, the relations of the peritoneum vary from that which has just been described, in that the peritoneal covering of the left lobe passes over the anterior border of the liver, invests the concave lower surface, and again becomes parietal by returning to the diaphragm as the inferior (posterior) layer of the coronary ligament, while to the right of the porta hepatis the peritoneum invests the lower surface of the liver and then passes partly to the diaphragm and partly to the anterior surface of the right kidney, the result being that the posterior surface of the right lobe remains uncovered by peritoneum (see page 59, Fig. 388).

The peritoneum passing to the stomach and upper portion of the duodenum by way of the lesser omentum invests both surfaces of the organs, and consequently runs from the lesser to the greater curvature of the stomach. From the fundus of the stomach it is reflected to the hilus of the spleen and to its gastric surfaces as the *gastrosplenic* ligament (Figs. 394, 404, and 413), and after investing the entire diaphragmatic surface of the organ and curving around its renal surface, it passes to the diaphragm as the *lienophrenic ligament*.

From the greater curvature of the stomach the peritoneum hangs down as a long apron-like duplicature which conceals the colon and the coils of small intestine and is termed the *great* or *gastrocolic omentum* (Figs. 407 to 409). The length and development of this structure is subject to manifold variations and its lower margin is usually irregularly notched. It consists originally of four layers of peritoneum (Fig. 402) which, during the course of development, become fused into two and include a cavity which is part of the bursa omentalis (Fig. 403). The layer which comes from the anterior surface of the stomach furnishes the most anterior of the four layers of the great omentum, turns upon itself at the lower margin of this structure, and now becomes the most posterior layer (Fig. 403). This is adherent to the transverse colon (see page 73), so that the peritoneum from the posterior surface of the great omentum is reflected upon that organ, which is placed almost transversely in the middle of the abdominal cavity and has attached to it a long mesentery proceeding from the posterior abdominal wall, the *transverse mesocolon* (Figs. 403, 409, and 410). This separates the upper portion of the abdominal cavity containing the stomach, the duodenum, the liver, and the spleen from the lower portion, in which are situated the small and large intestines, and when fully developed it consists of four adherent layers (Fig. 403), the two lower layers forming the true mesocolon and containing between them lamina proprii mesen-

terii, while the two upper layers form the floor of the bursa omentalis (see page 73) and belong to the great omentum. The transverse mesocolon is not exactly horizontal, but is directed from above downward and from behind forward (especially the upper surface). It is longest in the median line and becomes considerably shorter as it approaches the flexures, gradually passing into the ascending and descending mesocolon (see below).

To the left of the lesser omentum the posterior layer of the coronary ligament of the liver (or of the left triangular ligament) passes, as has already been stated, to the diaphragm, from which it is reflected to the spleen as the lienophrenic ligament. From the left margin of the great omentum, which extends from the stomach to the hilus of the spleen, a rather firm and dense fold of peritoneum, the *phrenicocolic ligament* (Fig. 405), practically always connects the splenic flexure of the colon with the adjacent surface of the abdominal wall (the costal origins of the diaphragm), and in the upright position of the body this ligament supports the lower extremity of the spleen.

To the right of the hepatoduodenal ligament the posterior layer of the coronary ligament (or of the right triangular ligament, see page 74) passes to the diaphragm, from which it is reflected as a parietal layer to the right kidney and suprarenal body, and thence to the region of the hepatic flexure of the colon. The relations of this portion of the peritoneum are acquired secondarily (see page 72).

From the posterior abdominal wall immediately below the origin of the transverse mesocolon the mesentery of the small intestine arises (Figs. 409 and 410). Its origin from the posterior parietal peritoneum is called the *root of the mesentery*, and consists of a duplicature approximately as wide as the hand, which arises at the left side of the second lumbar vertebra from the abdominal aorta and inferior vena cava and extends downward and to the right to the upper margin of the right sacroiliac articulation. The root of the mesentery is consequently obliquely placed in front of the vertebral column. It is short, but the edge of the mesentery attached to the small intestine is as long as this structure, *i. e.*, about six meters, and the mesentery is consequently folded upon itself again and again, so that it resembles a fan (Fig. 410). Its lamina propria is usually rich in fat and contains the ramifications of the superior mesenteric vessels and numerous mesenteric lymphatic glands, the root of the mesentery containing the trunks of these vessels and, like them, being situated in front of the inferior portion of the duodenum. The mesentery is of almost uniform width throughout the greater portion of the small intestine, but it gradually becomes shorter toward its upper and lower extremities, that is to say, at the duodeno-jejunal flexure and at the ileocæcal junction.

To either side of the root of the mesentery the structures upon the posterior abdominal wall may be seen through the peritoneum which extends to the ascending and descending colons and supplies them with a peritoneal envelope, that portion passing to the descending colon being called the descending mesocolon (Fig. 409), while that to the right of the root of the mesentery forms the ascending mesocolon. All portions of the colon originally possess a mesentery, but all of the descending mesocolon and the greater portion of the ascending mesocolon subsequently become adherent to the parietal peritoneum (see page 72). The cæcum retains a mesocæcum which varies markedly in different individuals, frequently being quite short, and the appendix also usually has a *mesenteriolum* (Fig. 415).

Behind the ascending mesocolon are situated the lower segment of the descending portion, the inferior flexure, and the commencement of the inferior portion of the duodenum, as well as a portion of the head of the pancreas, which receives its peritoneal covering only from the ascending mesocolon. Behind the descending mesocolon are found the lower portion of the right kidney, the ascending portion of the duodenum, and the adjacent horizontal portion up to the point where it is crossed by the root of the mesentery. Through the ascending and descending mesocolons may be seen the relief of the psoas muscles and also the bifurcation of the abdominal aorta into the common iliac arteries (Fig. 409).

While the descending colon is firmly attached to the posterior abdominal wall and covered by peritoneum only upon its anterior surface, the sigmoid colon holds a relation to the peritoneum similar to that of the transverse colon, *i. e.*, it protrudes into the peritoneal sac, possessing a slightly folded mesentery, known as the *sigmoid mesocolon* (Fig. 414), which becomes narrower toward its upper and lower extremities. With the sigmoid colon the peritoneum passes over the linea terminalis (pectineal line) into the pelvis in front of the promontory and becomes continuous with the peritoneal coat of the rectum, forming a short *mesorectum* for the upper portion of this structure.

To either side of the sigmoid colon the parietal peritoneum leaves the abdominal cavity and passes over the lateral and anterior portions of the pelvic inlet into the pelvic cavity, to be reflected partly upon the pelvic viscera and partly upon the surface of the pelvic floor. In this situation the relations of the peritoneum differ in the two sexes, since the female internal genitalia are partly invaginated into the peritoneal sac, while only a small portion of the male sexual organs come in immediate contact with it.

The rectum is invested by peritoneum upon its posterior surface only as far down as the level of the second sacral vertebra, since the mesorectum, which is attached to the first sacral vertebra, gradually becomes narrower and the peritoneal coat finally ceases. Laterally, and particularly anteriorly, the peritoneum extends to a lower level, so that the rectum lies obliquely to the line of the peritoneal reflection (Figs. 480, 481). In the male the peritoneum is reflected from the anterior surface of the rectum to the posterior surface of the bladder in such a manner that it usually invests the upper extremities of the seminal vesicles (Fig. 403), thus forming a rather deep recess between the bladder (or the seminal vesicles and ampullæ of the vasa deferentia) and the rectum, the *rectovesical pouch* (Figs. 480 to 483).

In the female the peritoneum holds the same relation to the rectum as is the case in the male. Instead of being reflected from the anterior rectal wall to the bladder, however, it passes to the uterus (Fig. 411) and the upper portion of the posterior vaginal vault (see page 149), and forms a peritoneal investment for the uterus, tubes, and ovaries, known as the *broad ligaments*. In this manner a deep pocket is formed between the anterior surface of the rectum and the posterior surface of the uterus, the *recto-uterine pouch* (*pouch of Douglas*) (Figs. 500 to 503).

The *broad ligament of the uterus* (Fig. 504) is an approximately frontal duplicature of peritoneum which passes from the lateral wall of the true pelvis and the lateral circumference of the pelvic inlet to the lateral border of the uterus, embracing within its layers the uterus and its adnexa. In the ligaments there may be recognized: (1) the middle portion, which furnishes the

peritoneal coat of the uterus, the *mesometrium;* (2) the upper portion, which invests the Fallopian tubes, the *mesosalpinx;* (3) and the portion passing to the ovary, the *mesovarium.* When put upon the stretch each broad ligament is approximately pentagonal. Its upper border is the longest and contains the Fallopian tube surrounded by the mesosalpinx; it is curved to correspond with the course of the Fallopian tube, and the inner uterine border is almost at a right angle.

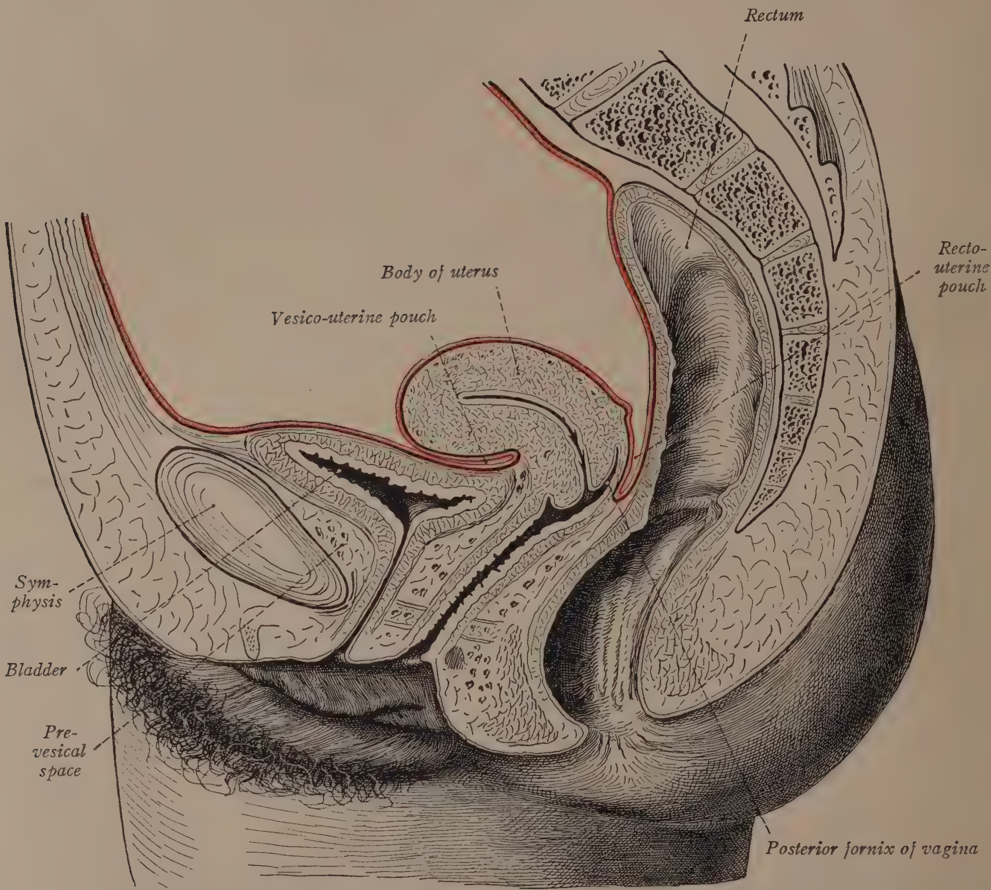


FIG. 411.—Arrangement of the peritoneum in the female pelvis, as seen in median section. The peritoneum is represented in red.

The inferior border, where the broad ligament becomes continuous with the parietal peritoneum, also makes approximately a right angle with the internal border, and the lower portion of the lateral border, in which the peritoneum of the broad ligament becomes continuous with that of the lateral pelvic wall, joins the inferior border at an obtuse angle. The upper portion of the lateral border is free; it joins both the lower portion of the lateral border and the upper border

at an obtuse angle and belongs to the mesosalpinx. It is formed partly by the fimbria ovarica and partly by the suspensory ligament of the ovary. The upper border of the broad ligament is about twice as long at the lower one; its height approximately corresponds to the breadth of the inferior border.

As regards its structure the broad ligament is composed of two layers separated by connective tissue and vessels; one is directed anteriorly and externally (according to the position of the uterus, see page 149) and one posteriorly and internally. The anterior layer contains the round ligament of the uterus; the posterior layer contains the ovarian ligament and gives off the mesovarium as a secondary fold. That portion of the broad ligament situated above the ovary and ovarian ligament is the mesosalpinx, and the portion below these structures is called the *perimetrium;* it contains the vessels passing to the uterus and becomes continuous with the *parametrium* at the lower margin of the broad ligament (see page 150). The mesosalpinx contains the epoöphoron and the paroöphoron (see page 147).

As a result of the curvature of the Fallopian tube in the upper margin of the broad ligament there is formed a narrow cleft-like pocket between the mesosalpinx and the external surface of the ovary, the *bursa ovarii.* In this pocket is situated the ovary, which is attached to the broad ligament only by the narrow mesovarium. Internally toward the uterus the bursa ovarii frequently becomes continuous with a fold running parallel to the ovarian ligament.

Since the broad ligaments are much longer than the distance between the lateral margin of the uterus and the lateral pelvic wall, they must necessarily pursue a curved course. They are consequently convex posteriorly, and their anterior surfaces are also directed externally and their posterior surfaces internally. According to the degree of vesical distention and the position of the uterus (see page 149) the anterior surface of the broad ligament is directed more downward and the posterior surface more upward. At the upper margins of the Fallopian tubes and at the fundus of the uterus the peritoneum of the anterior layer of the broad ligament as well as the peritoneum of the uterus (see page 149) becomes continuous with that upon the posterior surface of these structures.

In the female pelvis the broad ligament, the uterus and its adnexa form a frontal partition between the posterior portion, containing the rectum, and the anterior portion, containing the bladder. The peritoneum is reflected from the anterior inferior surface of the body of the uterus to the posterior surface of the bladder in such a manner as to leave a capillary space between the two surfaces, the *vesico-uterine pouch* (Figs. 411, and 500 to 503).

The bladder holds approximately the same relation to the peritoneum in both sexes. Only its posterior surface and the upper portion of its lateral surfaces are covered by peritoneum (see page 122), and at its vertex the peritoneum invests the ligaments, and is reflected to the anterior abdominal wall, becoming parietal.

The posterior surface of the anterior abdominal wall exhibits certain shallow fossæ known as the *inguinal fossæ* (Fig. 412), which are more pronounced in the new-born than in the adult.* The middle umbilical ligament passing from the vertex of the bladder to the umbilicus (see page 121) is invested by the peritoneum to form the *median umbilical fold*, and the lateral umbilical

* These fossæ are deeper in the new-born, since the umbilical ligaments contain unobliterated structures (the urachus and the hypogastric arteries) and are much more prominent than in the adult.

ligaments are similarly responsible for the *lateral umbilical folds*. To the outer side of each lateral umbilical fold there is still another fold, which is but slightly marked, and gradually disappears as it passes upward. It is produced by the inferior epigastric artery, which runs upward upon the posterior surface of the rectus abdominis.

The innermost of the fossæ, that situated between the median and lateral umbilical folds, is the deepest and is termed the *supravesical* (*internal inguinal*) *fossa*. The adjacent fossa, between the lateral umbilical and the epigastric folds, has no superior boundary; it is known as the *middle inguinal fossa*. The third and outermost fossa is the shallowest and the least marked of the three, and is situated in the angle formed by the epigastric fold and the posterior surface of the inguinal (Poupart's) ligament; it is known as the *external inguinal fossa*. It corresponds to the location of the internal abdominal ring, while the external abdominal ring (see Vol. I, page 158) is situated opposite the internal inguinal fossa.*

The peritoneum which has just been described forms the so-called greater peritoneal sac, in contradistinction to the more deeply placed lesser peritoneal sac or bursa omentalis. This latter (Figs. 403, 406, and 413) is essentially an elongated pocket, situated between the posterior surface of the stomach and the anterior surface of the pancreas, which communicates with the greater peritoneal sac through the *epiploic foramen* (*foramen of Winslow*, Fig. 406). This foramen is situated at the right margin of the hepatoduodenal ligament (of the lesser omentum), and is either elliptical or circular, about the size of a half-dollar, and bounded elsewhere by parietal peritoneum. Two additional ligaments may frequently be recognized in this situation and also aid in limiting this foramen: (1) the *hepatorenal ligament*, passing from the liver to the right kidney, and (2) the rarer *duodenorenal ligament*, extending between the right kidney and the duodenum. The epiploic foramen is situated between the caudate process of the liver and the superior portion of the duodenum.

Just within the foramen is situated the *vestibule* of the bursa omentalis (Fig. 413), the transverse diameter of which is quite small. It is placed behind the lesser omentum and corresponds in size to the caudate lobe of the liver, the posterior surface of which it invests with peritoneum, a portion of it, known as the *superior recess* (Fig. 403), extending upward beneath the coronary ligament of the liver. The papillary process of the caudate lobe may usually be seen through the flaccid portion of the lesser omentum. The parietal peritoneum† which forms the posterior wall of the bursa omentalis invests the crura of the diaphragm, portions of the abdominal aorta and of the inferior vena cava, and the abdominal portion of the œsophagus.

Between the vestibule and the main portion of the bursa omentalis there is a distinctly constricted portion which is termed the isthmus of the bursa omentalis. It is produced by a more or less pronounced sickle-shaped fold, the *gastropancreatic fold* (Fig. 413), which passes from the upper margin of the pancreas to the gastric fundus and contains the gastric artery, a branch of the cœliac artery.

The greater portion of the bursa omentalis lies between the stomach and the pancreas, and its transverse diameter is many times greater than that of the vestibule. It provides a peritoneal covering for the posterior surface of the stomach, the anterior surface of the pancreas with the

* Below Poupart's ligament there is a depression corresponding to the femoral ring, the *fovea femoralis*.

† This layer of peritoneum was originally visceral, being a portion of the dorsal mesogastrium.

exception of the head of the viscus, the left suprarenal body, a portion of the renal surface of the spleen, and the upper portion of the left kidney.

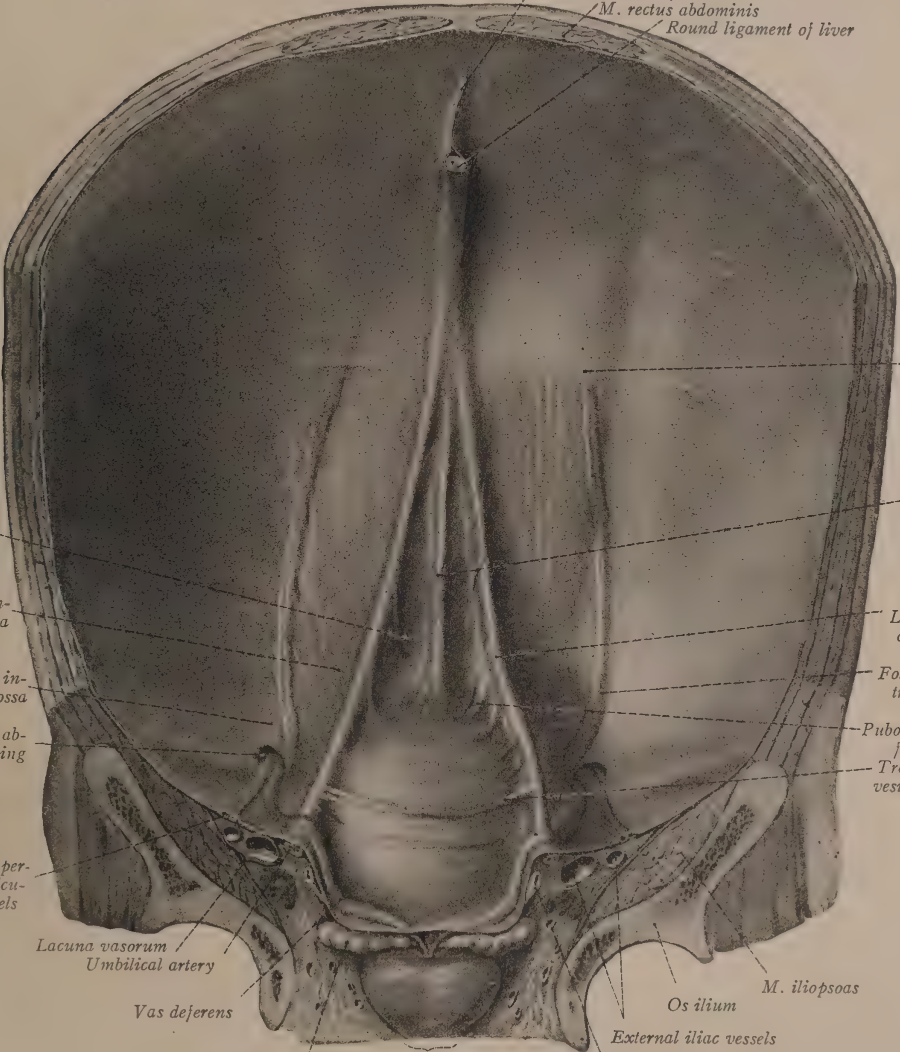


FIG. 412.—The anterior abdominal wall of a new-born child, together with the urinary bladder, seen from behind. The anterior abdominal wall has been removed by a frontal section passing through the hip-joint and by a horizontal section passing above the umbilicus.

FIG. 413.—The viscera resting on the posterior abdominal wall *in situ* in an eight-year-old boy.

The anterior abdominal wall, with the exception of its lower left portion, and the anterior part of the diaphragm have been removed by a frontal section. The stomach from the cardia to the pylorus has been removed so as to show the posterior wall of the bursa omentalis. The liver has been completely removed, and also the parietal peritoneum with the ascending and descending mesocolons, so that the kidneys, duodenum, the great vessels, and the muscles are exposed; only a small portion of the peritoneum has been left in the pelvic cavity. The diaphragm is represented covered by the fascia transversalis, but the fascia has been removed from the iliopsoas and quadratus lumborum. On the right side the inguinal canal has been laid open to show the spermatic cord; the bladder is distended; and the arteries have been injected with a red mass.

Toward the left the peritoneum of the bursa omentalis extends as far as the hilus of the spleen and forms the *splenic recess*, which is not marked off from the remainder of the bursa. There is also no sharp demarcation for the *inferior recess* of the bursa omentalis, which in the new-born extends to the tip of the great omentum, but usually becomes obliterated to a variable extent within the free portion of the great omentum, although it almost always persists within the gastrocolic ligament. By the secondary adhesion of the transverse colon and mesocolon (see page 73) to the posterior layer of the great omentum, these structures acquire a relation to the bursa omentalis and form its floor or posterior wall.

The peritoneum forms a large number of specially named duplicatures, some of which are quite inconstant. Many of them are known as folds or *plicæ*, while others are less appropriately designated as ligaments. Although the majority of these structures have been considered in the preceding description of the peritoneum, they will now be grouped together, and those which have not been previously mentioned will be briefly described:

1. The *falciform* (*suspensory*) *ligament* of the liver (see page 73).
2. The *coronary ligament* of the liver (see page 74).
3. The *triangular ligaments* of the liver (right and left, see page 74).
4. The *lesser omentum* (see page 75).
5. The *hepatogastric ligament* (see page 75).
6. The *hepatoduodenal ligament* (see pages 58 and 75).
7. The *hepatocolic ligament*, an inconstant expansion of the hepatoduodenal ligament extending to the transverse colon.
8. The *hepatorenal ligament* (see page 83).
9. The *duodenorenal ligament* (see page 83).
10. The *lienophrenic ligament* (see page 75).
11. The *gastrosplenic ligament* (see page 75).
12. The *phrenicocolic ligament* (see page 76).
13. The *gastrocolic ligament* (see page 75).
14. The *greater omentum* (see page 75).
15. The *transverse mesocolon* (see page 75).*
16. The *gastropancreatic fold* (see page 83).
17. The *mesentery* and *root of the mesentery* (see page 76).
18. The *duodenomesocolic fold* forms the inferior boundary of the duodenojejunal recess.

* The ascending and descending mesocolons do not appear as independent structures in the adult.

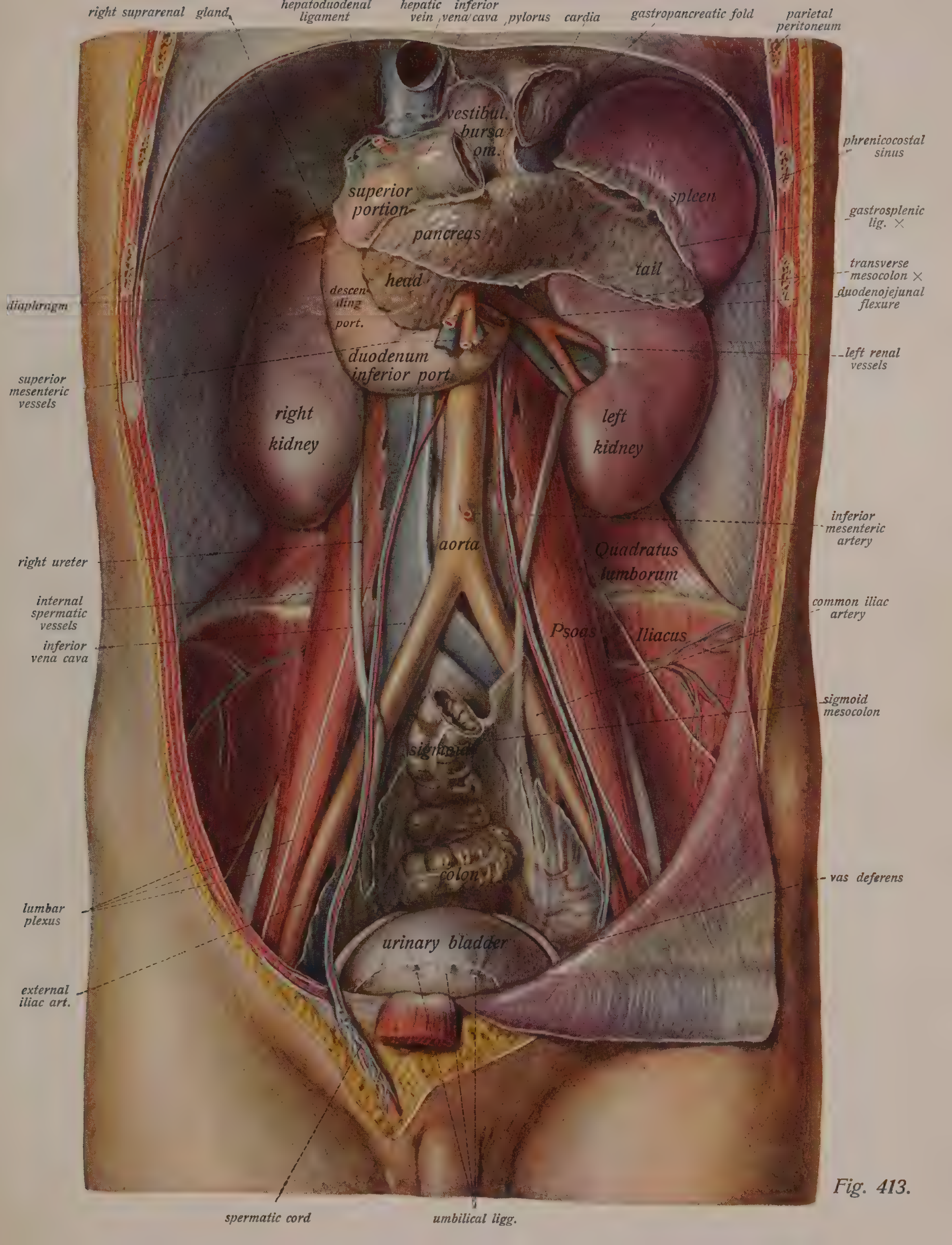

right suprarenal gland
hepatoduodenal ligament
hepatic vein
inferior vena cava
pylorus
cardia
gastropancreatic fold
parietal peritoneum
vestibul. bursa om.
phrenicocostal sinus
superior portion
spleen
pancreas
gastrosplenic lig. ×
tail
transverse mesocolon ×
head
descending port.
duodenojejunal flexure
diaphragm
duodenum inferior port.
left renal vessels
superior mesenteric vessels
right kidney
left kidney
inferior mesenteric artery
aorta
Quadratus lumborum
right ureter
internal spermatic vessels
common iliac artery
Psoas
Iliacus
inferior vena cava
sigmoid mesocolon
sigmoid
colon
vas deferens
lumbar plexus
urinary bladder
external iliac art.
spermatic cord
umbilical ligg.

Fig. 413.

19. The *duodenojejunal fold* forms the superior boundary of the recess of the same name and sometimes contains the inferior mesenteric vein.
20. The *cæcal fold* (Fig. 415) fixes the outer wall of the cæcum to the parietal peritoneum and limits the cæcal recess.
21. The *ileocæcal fold* (Fig. 415) limits the inferior ileocæcal recess, passing from the terminal portion of the ileum, opposite its mesenteric attachment, to the base of the appendix or to its mesenteriolum. It contains non-striated muscle.

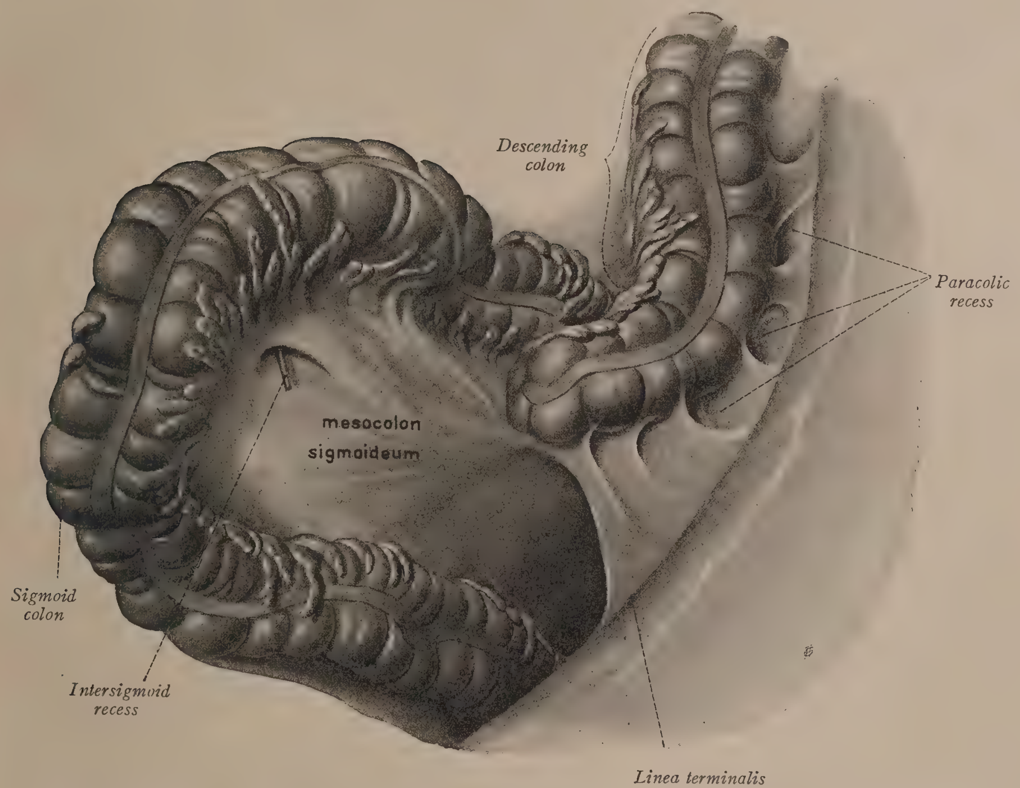


FIG. 414.—The peritoneal recesses in the neighborhood of the descending and sigmoid colons. The sigmoid colon has been drawn upward and to the right, so that its mesocolon is stretched out.

22. The *mesocæcum* (see page 76).
23. The *mesenteriolum of the appendix* (Fig. 415) passes to the upper margin of the appendix and to the mesocolic band of the cæcum.
24. The *sigmoid mesocolon* (see page 77).
25. The *mesorectum* (see page 77).

FIG. 416.—Transverse section through the upper part of the abdominal cavity at the level of the tenth thoracic vertebra.

FIG. 417.—Transverse section through the middle part of the abdominal cavity at the level of the fibro-cartilage between the second and third lumbar vertebræ.

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26. The *rectovesical fold*. This is present only in the male. It is a sickle-shaped fold containing the muscle of the same name, and passes from the anterior surface

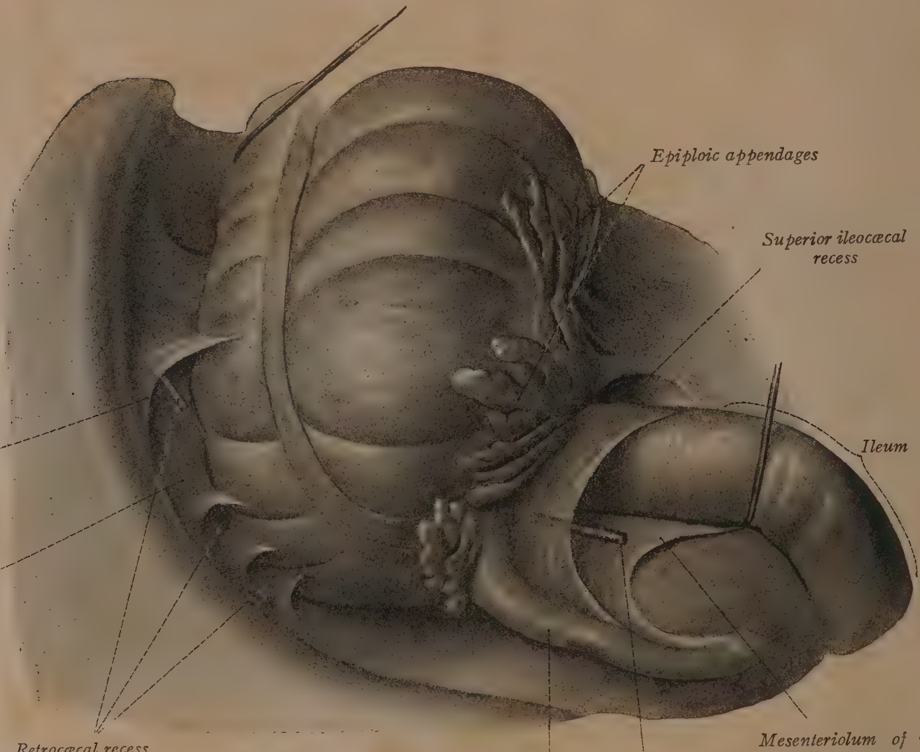

FIG. 415.—The peritoneal recesses in the neighborhood of the cæcum and the lower portion of the ileum. A sound has been inserted into the inferior ileocæcal recess.

of the rectum to the bladder, forming the lateral boundary of the rectovesical pouch. During childhood it is usually single, since the two folds are fused at the lower portion of the bladder.

27. The *rectouterine fold* (Figs. 417, 418 and 420, and 421). This is present only in the female. It is a paired fold containing the muscle of the same name, and passes

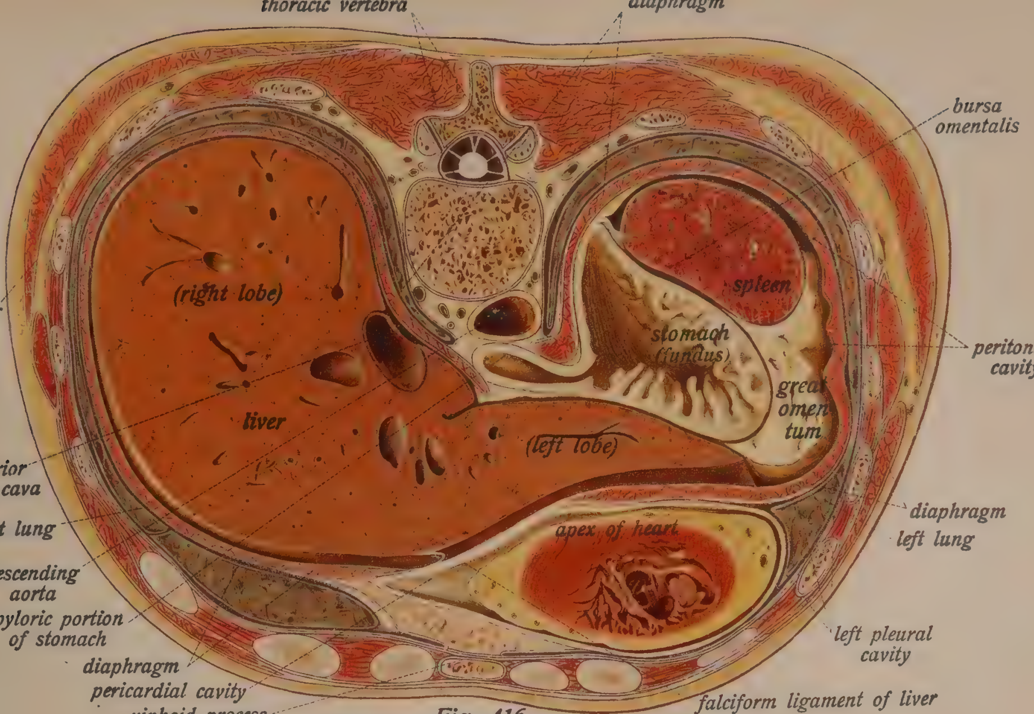

Fig. 416.

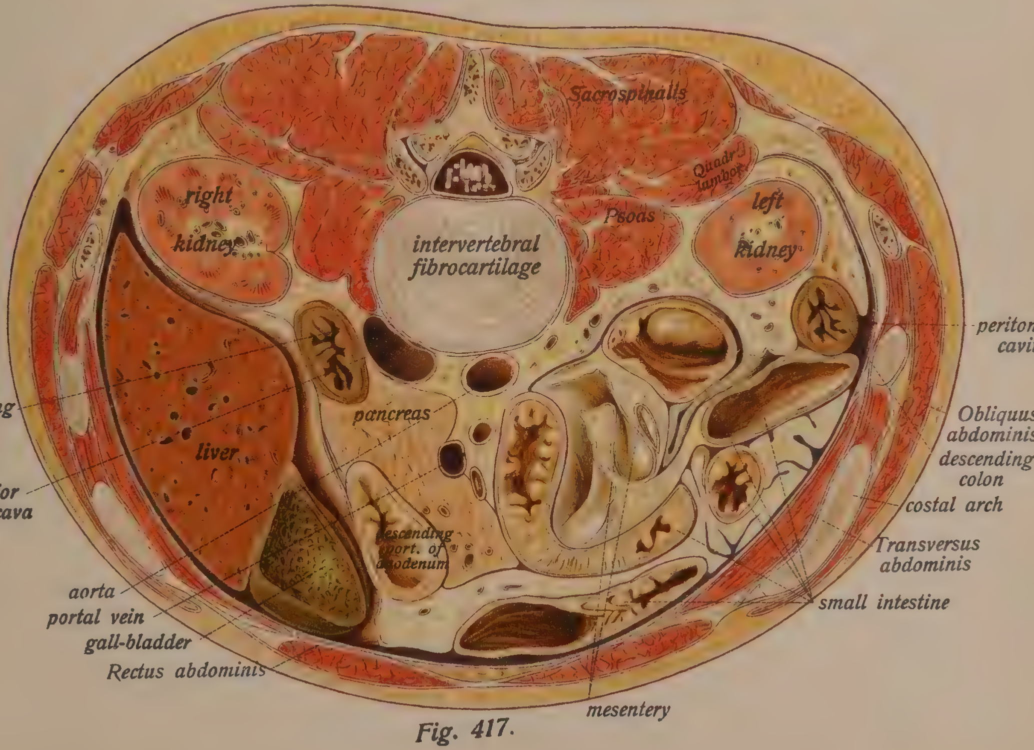

Fig. 417.

from the anterior surface of the rectum to the base of the broad ligament, forming the lateral boundary of the pouch of Douglas.

28. The *broad ligament* of the uterus as well as the *mesosalpinx*, the *mesovarium*, etc. (see page 77).
29. The *transverse vesical fold* (Fig. 412), passing over the empty bladder.
30. The *pubovesical fold* (Fig. 412), often present in numbers in the supravesical fossa, at the site of the reflection of the peritoneum from the posterior surface of the pubic bone to the vertex of the (empty) bladder.
31. The *median umbilical fold* (see page 81).
32. The *lateral umbilical fold* (see page 81).
33. The *epigastric fold* (see page 81).

In addition to the bursa omentalis, the peritoneum forms a series of smaller pockets or recesses which vary greatly both in reference to their size and frequency. The most important of these are the following:

1. The *bursa omentalis* (see page 82).
2. The *duodenojejunal recess* (Fig. 409) to the left of the vertebral column; bounded above by the duodenojejunal fold, below by the duodenomesocolic fold.
3. The *inferior ileocæcal recess* (Figs. 409, 410, and 415), an inconstant but usually deep fossa, which opens inferiorly and toward the median line. It is bounded above by the ileocæcal fold, to the right by the cæcum, and below and behind by the mesenteriolum of the appendix.
4. The *superior ileocæcal recess* (Fig. 415), an inconstant shallower pouch at the upper border of the ileocæcal junction. It is bounded by the ileum, the cæcum, and an inconstant fold of peritoneum containing the ileocolic artery.
5. The *cæcal recess* (Fig. 415), a recess in the parietal peritoneum which is open below and lodges the cæcum. It is bounded above and to the right by the cæcal fold.
6. The *retrocæcal recess* (Fig. 415), small inconstant pockets which proceed from the upper portion of the cæcal fossa or are situated alongside the right margin of that portion of the ascending colon which is adjacent to the cæcum.
7. The *paracolic recess* (Fig. 414), similarly shaped small inconstant pockets at the left margin of the descending mesocolon.
8. The *intersigmoid recess* (Fig. 414), an inconstant funnel-shaped pocket which is rarely very deep. It is situated at the root of the sigmoid mesocolon and opens downward and toward the left.
9. The *rectovesical pouch* (see page 77).
10. The *rectouterine pouch* (see page 77).
11. The *bursa ovarica* (see page 80).
12. The *vesicouterine pouch* (see page 80).
13. The *vaginal process* (an embryonic structure, see page 128).
14. The *supravesical fossa* (see page 81).
15. The *internal inguinal fossa* (see page 81).
16. The *external inguinal fossa* (see page 82).

FIG. 418.—Skeleton of the nose seen from the right and somewhat from above.
FIG. 419.—Skeleton of the nose seen from in front.
FIG. 420.—Skeleton of the nose seen from below.
FIG. 421.—Nasal septum seen from the right side.
FIG. 422.—The median wall of the nasal cavity seen from the right side.
The mucous membrane has been removed from the anterior portion.

The space between the posterior parietal peritoneum and the muscles and bones forming the posterior abdominal wall is known as the *retroperitoneal space*. It does not constitute a cavity throughout any portion of its extent, but is filled with viscera, vessels, nerves, and fatty tissue. Among other things it contains the kidneys and suprarenal bodies, the ureters, the internal spermatic vessels, the aorta and its branches, the inferior vena cava, the branches of the lumbar plexus, and the sympathetic nerves with their plexuses.

The prevesical space will be described at page 123.

THE RESPIRATORY APPARATUS.

The respiratory tract in the broadest sense includes the nasal cavity, the larynx, the trachea with its ramifications, and the lungs (Fig. 323), but in a restricted sense only the larynx, the trachea, and the lungs are regarded as respiratory organs. The nasal portion of the pharynx also serves as an air-passage and consequently may be considered a portion of the respiratory apparatus, while the upper portion of the nasal fossa is the seat of the sense of smell, just as portions of the oral mucous membrane are the seat of the sense of taste. The oral cavity also may occasionally be used as an air-passage. The respiratory organs appear to be an appendage of the digestive tract; as a matter of fact, they arise as gland-like formations of the foregut (see page 105), while the greater portion of the nasal fossæ has a common origin with the oral cavity (see pages 21 and 90). In describing the nasal fossæ it is customary to include the nose, and the thyreoid and thymus glands are usually considered with the actual organs of respiration.

THE NOSE (NASUS EXTERNUS).

There may be recognized in the nose (Fig. 324) a *base*, which is directed downward, and a *root*, situated between the two orbits; the rounded anterior surface is directed forward and upward and is termed the *dorsum*, and it terminates in the *tip* of the nose, or *apex nasi*. The margins representing the lower borders of the base pass backward from the tip to form the *alæ*, and they constitute the lateral boundaries of the *nostrils* (*nares*), which are separated from each other by the antero-inferior portion of the nasal septum, the *membranous septum*.

The *skeleton of the nose* (Figs. 418 to 421) is formed partly by bones (see Vol. I, pages 76 and 77) and partly by cartilages, the latter consisting of the single cartilaginous septum, the anterior continuation of the bony nasal septum (see Vol. I, page 77), and of a series of paired cartilages.

The *cartilaginous nasal septum* (Fig. 421) is a rather thin, rarely quite even, irregularly quadrilateral plate which is attached to the anterior margin of the vomer (see Vol. I, page 66) and the inferior margin of the perpendicular plate of the ethmoid (see Vol. I, page 63). Inferiorly it

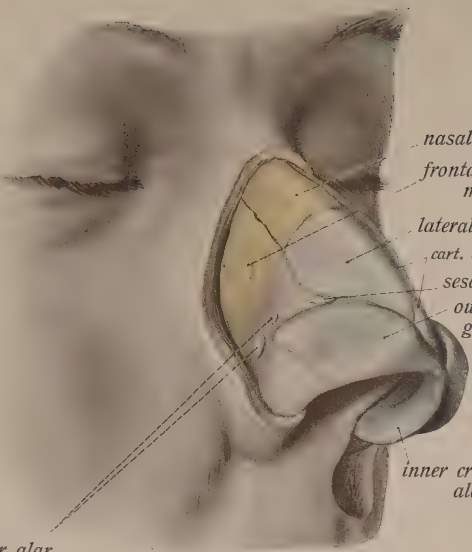

Fig. 418.

Fig. 419.

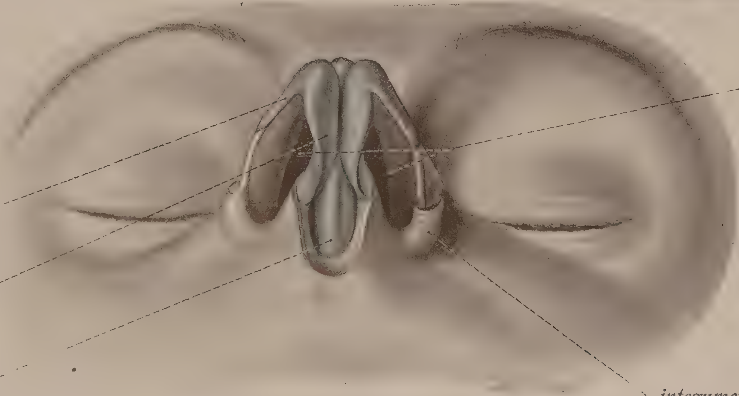

Fig. 420.

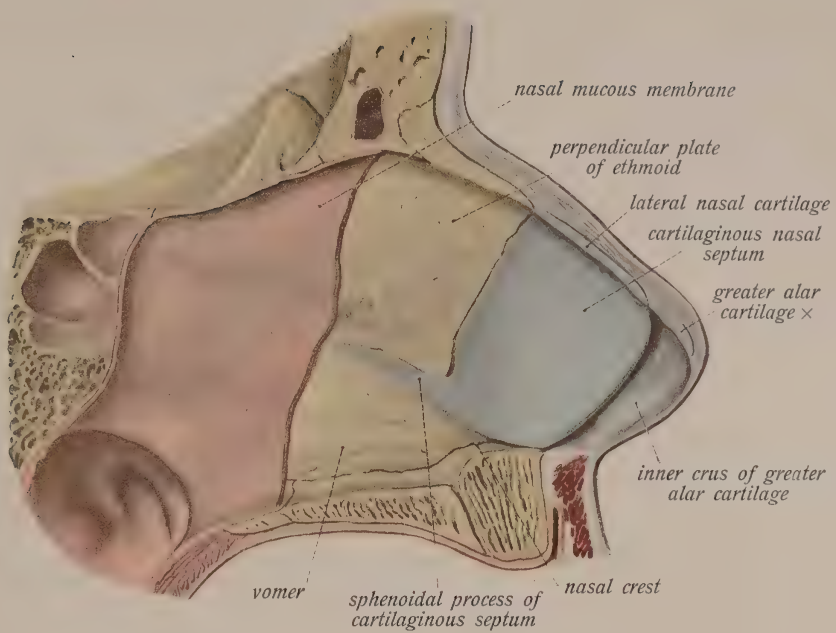

Fig. 421.

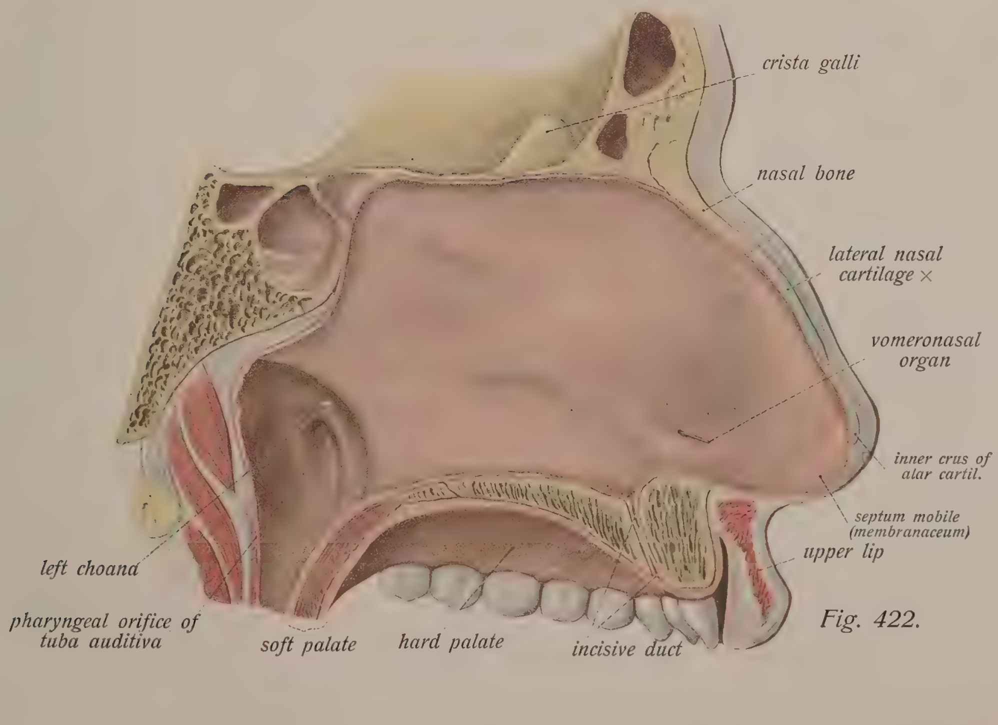

Fig. 422.

does not quite reach to the nostrils, but terminates above them by a free margin which is indicated by a shallow groove on the mucous membrane, so that a small portion of the nasal septum is membranous, and is known as the *membranous* or *mobile septum*.* The nasal septum is usually somewhat bent toward one side and this deviation is frequently very pronounced.

The *lateral nasal cartilages* (Figs. 418 and 419) seem to be the direct continuation of the cartilaginous septum, since upon the dorsum of the nose they are fused not only with each other, but also with the upper portion of the anterior margin of the septum. They are flat triangular plates forming the antero-inferior portion of the lateral nasal wall, and are fixed by connective tissue to the anterior margins of the nasal bones and nasal processes of the maxillæ. Inferiorly they do not extend to the nostrils, but are loosely connected with the cartilages of the alæ of the nose.

The *greater alar cartilages* (Figs. 418 to 420) are two cartilaginous strips which are curved around the anterior ends of the nostrils; each is composed of an inner and an outer crus, which are continuous with each other at the tip of the nose. The outer crus is much wider than the inner, is applied to the lower extremity of the lateral cartilage, and follows the upper border of the ala of the nose, forming its anterior portion and also the tip of the nose. The much narrower inner crus is situated in the membranous septum at the lower margin of the cartilaginous septum, with which it is loosely connected. Both inner crura are in contact in the median line.

The *lesser alar cartilages* (Fig. 418) are rather constant small cartilages which are frequently double, and are placed above and behind the posterior extremity of the outer crura of the greater alar cartilages.

The *sesamoid nasal cartilages* (Fig. 418) are frequent but inconstant constituents of the dorsum and are situated between the two greater alar cartilages (outer crura) and the lower extremities of the lateral cartilages. In addition to these, the nasal skeleton also includes other smaller cartilages which are of rarer occurrence.

The nose possesses muscles (see Vol. I, page 182) as well as cartilages. The skin, particularly at the alæ, is rich in large sebaceous glands; it is very thin and delicate and contains practically no fat, and is firmly adherent to the underlying tissues in the region of the cartilaginous skeleton.

THE NASAL CAVITY.

The nasal cavity (Figs. 422 to 424), with the exception of the antero-inferior portion, which has a cartilaginous or membranous boundary, corresponds to the bony nasal cavity. It is divided by the septum into two symmetrical halves. Each of these has an anterior orifice, the nostril, and a posterior one leading into the pharynx, the choana (see page 41), and by this route the air passes through the nasal cavity to the pharynx and larynx.

The actual nasal cavity may be distinguished from the vestibule, which is practically enclosed by the cartilaginous nasal skeleton and is the area of transition of the integument into the nasal mucous membrane. Its lining near the nostril corresponds to the skin and contains large hairs

* The mobile septum nevertheless contains the inner crura of both greater alar cartilages. The cartilaginous septum frequently sends a process between the vomer and the perpendicular plate of the ethmoid; this process is termed the *sphenoidal process* of the cartilaginous septum (Fig. 421) and occasionally extends as far as the body of the sphenoid bone.

FIG. 423.—The lateral wall of the nasal cavity seen from the left.

FIG. 424.—The lateral wall of the nasal cavity seen from the left, the lower and middle conchæ being cut away.

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known as *vibrissæ*, and it is marked off from the main portion of the nasal cavity by a ridge, the *limen nasi*.

The actual nasal cavity has the same walls and boundaries that have previously been considered in the description of the bony cavity (see Vol. I, page 76), since the periosteum (or perichondrium as the case may be) is invested by mucous membrane which in certain situations is very thick and vascular. Consequently there may be recognized three *conchæ* (*turbinated bodies*), a superior, middle, and inferior concha, each of which contains the similarly named bone. Since these bones are enveloped in a thick mucous membrane the conchæ appear considerably more rounded than do the bony structures, and, projecting from the outer nasal wall, they subdivide the outer portion of the nasal cavity into the *superior*, *middle*, and *inferior meatus*, while the undivided portion situated between the free (internal) margins of the conchæ is known as the *common meatus* of the nose. Between the margins of the upper two conchæ and the septum, this meatus is usually nothing more than a slit.

A slight ridge-like elevation which passes toward the tip of the nose from the anterior extremity of the middle turbinated body is known as the *agger nasi* (Fig. 423) and is to be regarded as a rudimentary concha. Together with the anterior extremity of the inferior concha it bounds a space which is called the *atrium* of the middle meatus. The choana is considerably lower than the nasal cavity, so that only a portion of the latter can be seen through the choanæ from the nasal portion of the pharynx; as a rule, only the posterior extremities of the inferior and middle conchæ are visible, and it is only when the vertical diameter of the choanæ is unusually great that the upper ones also come into view. Above the superior concha there is usually a pocket which ends at the anterior surface of the body of the sphenoid and does not run to the choana; being, consequently, not an actual nasal meatus, it is known as the *sphenoethmoidal recess*. In this situation there is sometimes present a short *concha suprema*.

Since the conchæ are not as long as the entire nasal cavity, especially the upper two, there is a common space in front of both their anterior extremities; the anterior space is designated as the *carina* (Fig. 473), while the posterior one, situated immediately in front of the lateral border of the choana, is called the *nasopharyngeal meatus* (sulcus nasalis posterior), and is a shallow groove, usually quite indistinct.

A number of the openings into the bony nasal cavity (see Vol. I, page 77) which give passage only to vessels and nerves are closed by the nasal mucous membrane. This is the case, for instance, with the sphenopalatine foramen. The other openings, particularly the orifices of the accessory nasal cavities, are visible, although they are more or less modified and narrowed by the nasal mucous membrane which passes through them to line the cavities. In the inferior meatus, 2 or 3 cm. from the nostril and about 1 cm. above the floor, is situated a narrow slit, the lower orifice of the *nasolachrymal duct* (Fig. 424) (for further detail see under "Sense Organs"), and at either side of the anterior extremity of the nasal crest (see Vol. I, page 68) the floor of

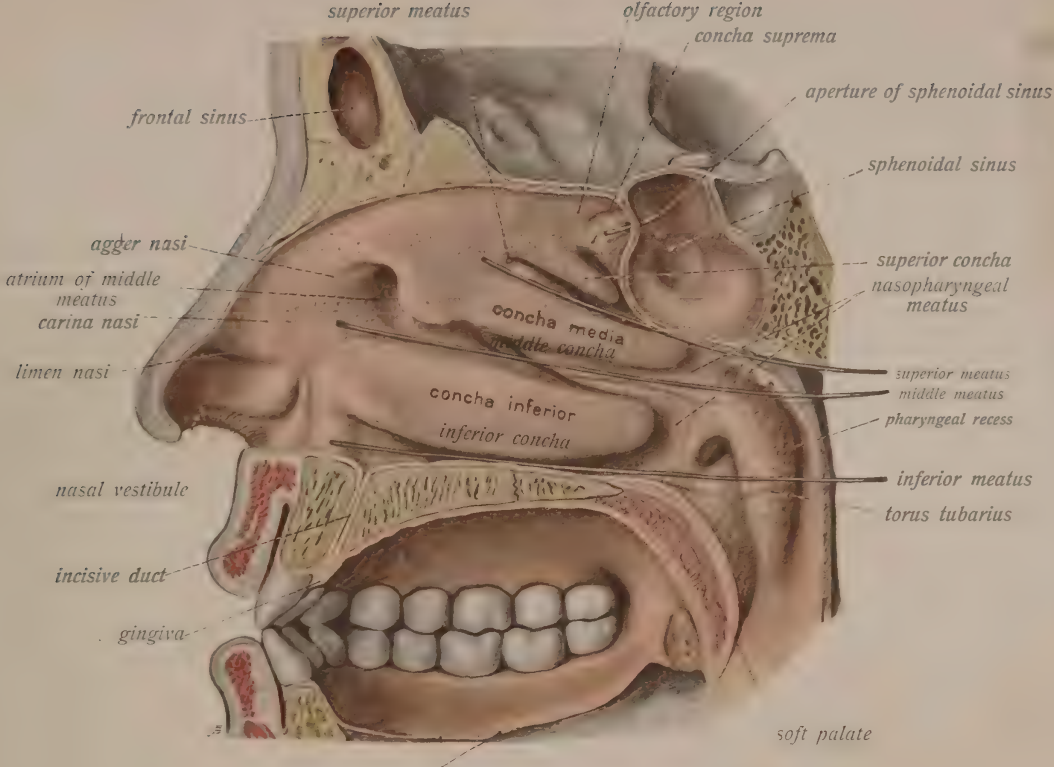

Fig. 423.

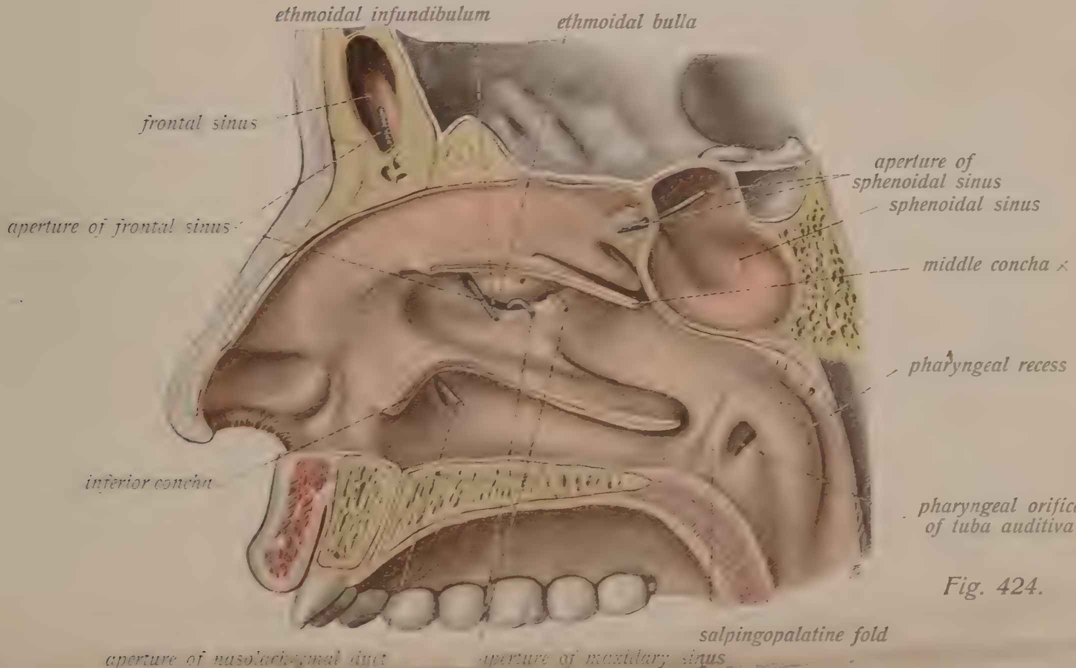

Fig. 424.

the cavity presents a protrusion of the mucous membrane into the incisive canal; in the human subject it forms a rudimentary duct, the *ductus incisivus* (*duct of Stenson*), which is usually entirely obliterated (Fig. 423).*

Behind and above the entrance into the incisive duct the mucous membrane of the nasal septum not infrequently contains a fine horizontal canal, the rudiment of an organ which is well developed in mammalia, the *vomeronasal* (*Jacobson's*) *organ* (Fig. 422). In the newborn this structure is usually well developed and is supplied by the olfactory nerve.†

Owing to differences in physiology and structure the nasal mucous membrane is divisible into two separate regions, the olfactory and the respiratory, although they are not sharply defined. The olfactory region is small and includes only the upper part of the nasal cavity, that is to say, the upper concha, and the portion of the septum upon the same level, although it extends slightly downward in certain situations. It is characterized by the possession of the olfactory glands. The entire remaining portion of the nasal cavity is lined by the thick, vascular, bright red mucous membrane of the respiratory region, which is intimately connected with the periosteum (or the perichondrium), and contains, particularly in the region of the lower two conchæ, close networks of large veins, the *venous plexus of the conchæ*, and also numerous nasal mucous glands. The venous plexuses of the nasal cavity act almost exactly like erectile tissue and are able to produce a considerable narrowing of the nasal passages.

THE ACCESSORY SINUSES OF THE NASAL CAVITY (SINUS PARANASALES).

The *accessory nasal sinuses* (*sinus paranasales*) (Fig. 424) correspond exactly to the previously described bony cavities (see Vol. I, page 77). They are lined by a very thin, pale mucous membrane, poor in glands,‡ which is adherent to the thin periosteum lining the cavities and is consequently readily separated from the bones. Their orifices into the main nasal cavity correspond to the bony apertures, but owing to the projecting margins of mucous membrane they are frequently considerably smaller than the same openings in the bony skeleton. The constant orifice of the maxillary sinus in the ethmoidal infundibulum is particularly narrow and cleft-like; there is not infrequently a second more rounded opening, however, beside the maxillary process of the inferior concha.

The accessory nasal sinuses are subdivided into the smaller ethmoidal cells and the larger frontal, sphenoidal, and maxillary sinuses (see Vol. I, page 47 *et seq.*).

The arteries of the nose are derived chiefly from the external maxillary and infraorbital; the anterior portion of the nasal cavity is supplied by the anterior ethmoidal branch of the ophthalmic, while the posterior portion is nourished by the sphenopalatine branches of the internal maxillary.

The chief veins of the nose are the angular and the infraorbital. The nasal cavity is drained by a large number of veins, some corresponding to the arteries, some anastomosing with those of the face, palate, pharynx, and the adjacent bones, and some passing to the pterygoid plexus. The lymphatics of the nose and of the anterior portion of the nasal fossa

* These ducts are well developed in the mammalia, but in the human subject they only rarely terminate by means of an opening in the incisive papilla of the hard palate.

† In this situation in the human subject there also occurs a narrow cartilaginous strip, the *vomeronasal cartilage*, which is usually also of rudimentary development.

‡ The mucous membrane of the accessory sinuses is not entirely free from these structures, but is scantily supplied with very small mucous glands.

FIG. 425.—Thyreoid cartilage seen from in front.
FIG. 426.—Thyreoid cartilage seen from the left side.
FIG. 427.—Cricoid cartilage seen from behind.
FIG. 428.—Cricoid cartilage seen from the side.
FIG. 429.—Arytenoid cartilage seen from behind.
FIG. 430.—Arytenoid cartilage seen from the medial surface.
FIG. 431.—The cartilage of the epiglottis seen from behind.
FIG. 432.—Epiglottis seen from behind.

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pass with those of the face to the submaxillary lymphatic glands; those of the posterior portion, together with those of the palate and pharynx, empty into the deep facial lymphatic glands.

The olfactory region is supplied by the olfactory nerves. The nerves for the anterior portion of the respiratory region as well as those for the accessory sinuses are derived partly from the ophthalmic division of the fifth (the anterior and posterior ethmoidal branches for the anterior portion of the nasal fossæ, the ethmoidal cells, the frontal sinus, and the sphenoid sinus) and partly from the superior maxillary division of the same nerve (the posterior portion of the nasal fossæ and the maxillary sinus).

During a certain period of embryonic life the nasal and oral cavities form a common space included within the oral invagination (see page 21), but the nasal cavity is subsequently separated from the mouth by the development of the palate. The first indication of the nasal cavity, and particularly of the olfactory region, however, is entirely independent of the mouth and consists of paired ectodermic formations, the so-called olfactory or nasal pits.

THE LARYNX.

The *larynx* (Figs. 425–442) is an irregular tubular dilatation of the respiratory tract proper which connects the pharynx with the trachea and transmits air to the actual respiratory passages. It is situated in front of the laryngeal portion of the pharynx in the so-called laryngeal region of the neck, and is opposite the lower three cervical vertebræ; superiorly it is intimately connected with the hyoid bone and inferiorly with the trachea. In the median line its anterior wall is immediately beneath the cervical integument, from which it is separated only by the superficial layer of the deep cervical fascia and, in the male sex particularly, it produces the so-called *laryngeal prominence* (Adam's apple). The lateral portions of the anterior laryngeal wall, as well as the lateral walls of the organ, are covered by the platysma, the sternohyoidei, the sternothyreoidei, the thyreohyoidei, the omohyoidei (anterior bellies), and partly by the thyreoid gland, and a portion of the laryngeal wall is also concealed by the constrictor pharyngis inferior, which arises from the laryngeal skeleton. The posterior laryngeal wall is invested by the pharyngeal mucous membrane (see page 42) and constitutes the anterior wall of the laryngeal portion of the pharynx.

The larynx consists of the laryngeal skeleton, which is formed by cartilages and provided with ligaments and joints, the laryngeal muscles, the mucous membrane, and the laryngeal vessels and nerves.

THE CARTILAGES OF THE LARYNX.

The skeleton of the larynx consists of three single (the *thyreoid*, the *cricoid*, and the *epiglottis*) and three or four pairs of cartilages (the *arytenoid*, *corniculate*, and *cuneiform carti-*

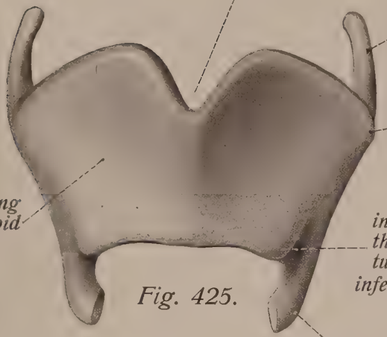

Fig. 425.

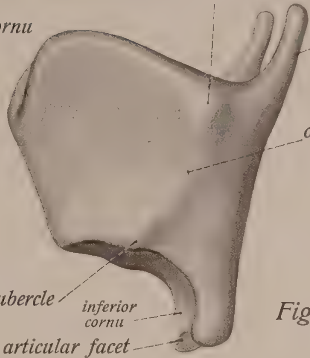

Fig. 426.

Fig. 427.

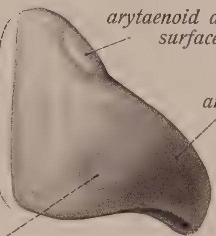

Fig. 428.

Fig. 429.

Fig. 430.

Fig. 432.

Fig. 431.

lages, and the *cartilagines triticeæ*). The individual cartilages are connected with each other partly by articulation and partly by synchondroses or syndesmoses.

The **thyreoid cartilage** (Figs. 425, 426, 433, 434, and 441) is by far the largest of all the laryngeal cartilages. Although a single structure, it is composed of two symmetrical plates, the right and left plates of the thyreoid cartilage, which are large, approximately quadrilateral plates forming the anterior and lateral walls of the larynx; their anterior margins meet at a right angle in the median line, forming the *laryngeal protuberance.* Above and below their junction the two plates are separated by a notch, the *superior* and *inferior thyreoid notches* respectively, and the posterior margins of the thyreoid plates are widely separated from each other, since the entire width of the cricoid cartilage is interposed between their lower extremities. The two thyreoid plates are consequently situated in positions midway between the frontal and sagittal planes; they converge anteriorly and diverge posteriorly. In each plate there may be recognized an external and an internal surface, the latter being directed toward the cavity of the larynx, and each plate also possesses a superior, a posterior, an inferior, and an anterior margin, the last named being fused with the corresponding margin of the plate of the opposite side. The almost straight posterior margin is the longest and its upper and lower extremities each exhibit a horn-like process which are designated as the *thyreoid cornua.* The superior cornua are longer than the inferior and are bent somewhat inward and backward; the shorter inferior cornua are directed inward and forward, and their inner surfaces exhibit a facet for articulation with the cricoid cartilage.

The middle of the upper margin of the thyreoid cartilage is marked by the superior thyreoid notch, and to either side the upper margin of each plate exhibits a convexity directed upward. Each side of the lower margin, in addition to the shallower inferior thyreoid notch, presents a slight concavity, the two structures being separated by the *inferior thyreoid tubercle.*

The inner surface of the thyreoid cartilage is smooth and presents no characteristic peculiarities. Each outer surface, however, exhibits a blunt projection near the posterior portion of the upper margin, the *superior thyreoid tubercle* (Fig. 426), from which the *oblique line*, a smooth elevation which is not always distinctly developed, passes obliquely downward and inward to the *inferior thyreoid tubercle*, situated upon the inferior margin. It gives origin (or insertion, as the case may be) to the sternothyreoid, thyreohyoid, and partly also to the thyreopharyngeus muscles (see page 43). One or both of the thyreoid plates not infrequently contains an opening which is termed the *thyreoid foramen.*

The **cricoid cartilage** (Figs. 427, 428, 433, and 434) is shaped like a signet-ring, the portion corresponding to the seal being posterior and the narrow portion anterior. The lower margins of the two portions are, however, situated in almost the same plane, while the upper margin of the seal portion is considerably above that of the narrow part, which is termed the *arch.* Near its root or junction with the seal portion upon either side, the outer surface of the arch shows an elliptical almost plane articular facet, the *thyreoid articular surface* (Fig. 428), for the inferior cornua of the thyreoid cartilage. This facet is situated upon a smooth elevation.

The seal portion or *lamina* of the cricoid cartilage is three or four times as high as the arch. Its posterior surface, which projects into the pharynx (see page 42), presents a low median ridge, to either side of which is visible a shallow depression (Fig. 427), and at its upper margin there are two elliptical, convex facets, the *arytenoid articular surfaces*, for articulation with the arytenoid cartilages. The lower margin of the cartilage sometimes presents a very short pointed projection

FIG. 433.—The ligaments and articulations of the larynx seen from in front.

FIG. 434.—The ligaments and articulations of the larynx seen from behind. Hyaline cartilage is colored blue; elastic cartilage and the hyoid bone, yellow.

FIG. 435.—Frontal section of the larynx.

FIG. 436.—Sagittal section of the larynx.

FIG. 437.—Transverse section of the larynx at the level of the glottis.

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at the junction of the plate with the arch, and since the lower margin of the lamina is upon approximately the same level as the lower margin of the arch, the upper margin of the latter ascends sharply as it passes into the lamina (Fig. 428). The cricoid cartilage forms the foundation of the entire laryngeal skeleton.

The **cartilage of the epiglottis** (Figs. 432 and 434), the remaining single laryngeal cartilage, is a thin single plate, curved almost like a saddle, which passes downward into a pedicle, the *petiole*. It is convex anteriorly and above and concave posteriorly and below, and is enveloped in mucous membrane, thus forming the epiglottis (Fig. 435). Its upper margin is usually notched in the median line and it is usually provided with pit-like depressions, and frequently with foramina, which lodge the glands contained in the investing mucous membrane. Its petiole is attached to the superior notch of the thyreoid cartilage (Fig. 434), its base forming the *epiglottic tubercle* at the entrance to the larynx (Fig. 435).

The only paired laryngeal cartilages of considerable size and importance are the arytenoids, the remaining partly inconstant cartilages being small and unimportant constituents of the laryngeal skeleton.

The **arytenoid cartilages** (Figs. 429 and 430) are small, pyramidal, very movable structures which articulate with the cricoid cartilage. The concave surface in contact with the upper margin of the cricoid is termed the *base*, the upper extremity the *apex*, and each cartilage possesses three surfaces, an internal, an external, and a posterior. The lower surface of the base presents a facet for articulation with the cricoid cartilage, and also two processes: the pointed and flat *vocal process*, which is situated at the lower end of the anterior margin, and is directed anteriorly and gradually disappears in the vocal cord, and the blunt, rounded *muscular process*, which is placed at the outer angle of the base and directed backward.

The apex of each arytenoid cartilage appears to be cut off transversely, and upon this surface is situated a *corniculate cartilage* which represents, so to speak, the absent tip of the arytenoid. The external surface of each arytenoid presents a horizontally curved ridge, the *arcuate crest* (Fig. 429), which separates two depressions, the upper of which is known as the *triangular fovea* and the lower as the *oblong fovea*, and just above the triangular fovea and near the anterior margin there is a rounded tubercle called the *colliculus*. The posterior surface is concave; the very narrow internal surface is almost flat and is directed toward the median line, the two arytenoid cartilages being in contact by means of their internal surfaces except superiorly, where the internal surface ceases to exist as such.

The **corniculate cartilages** (*cartilages of Santorini*) (Figs. 429 and 430) are situated upon the apices of the arytenoids; they are small pyramidal bodies, directed inward and backward,

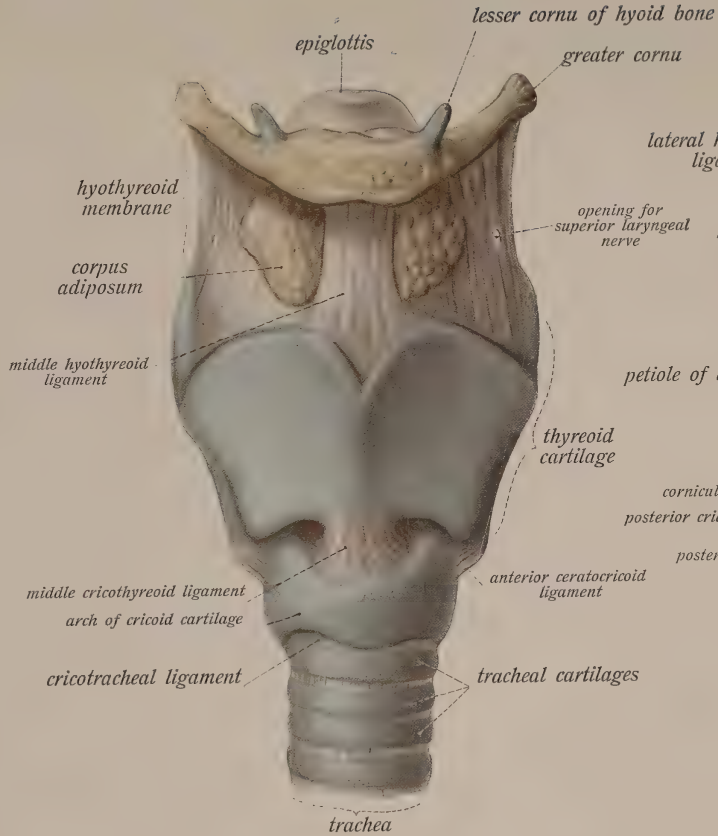

Fig. 433.

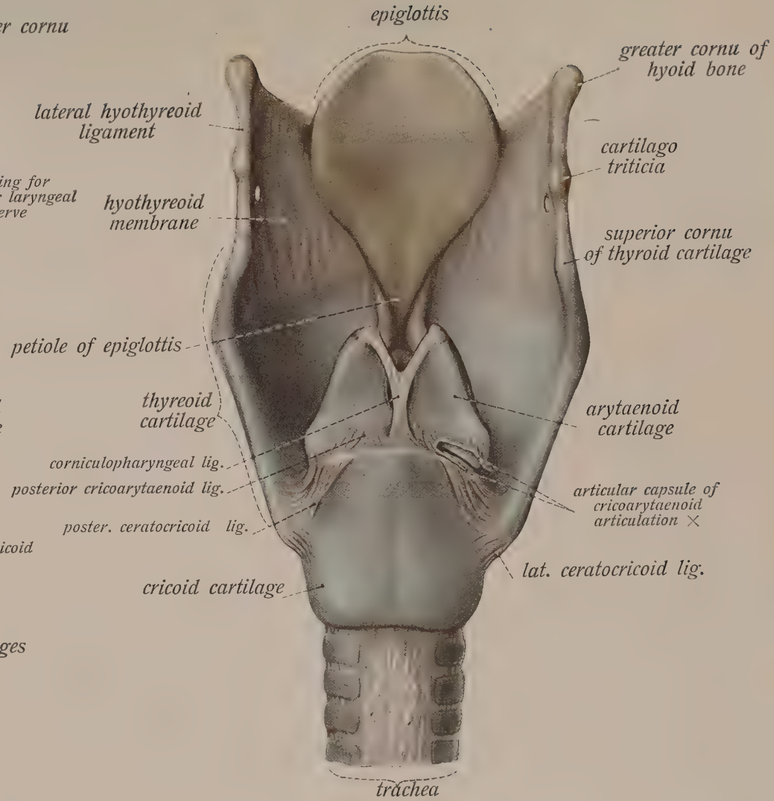

Fig. 434.

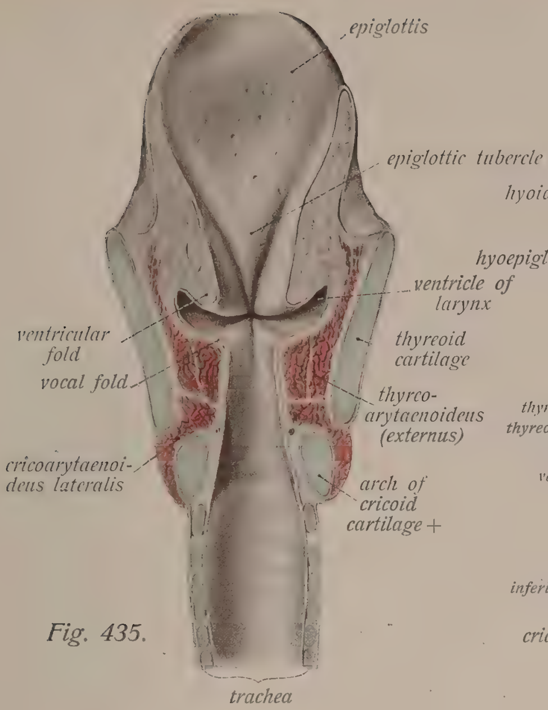

Fig. 435.

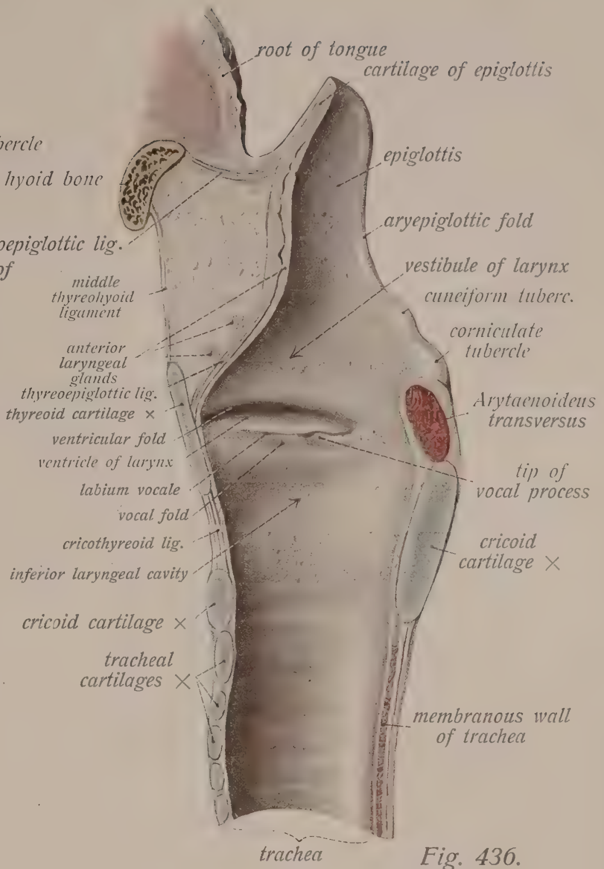

Fig. 436.

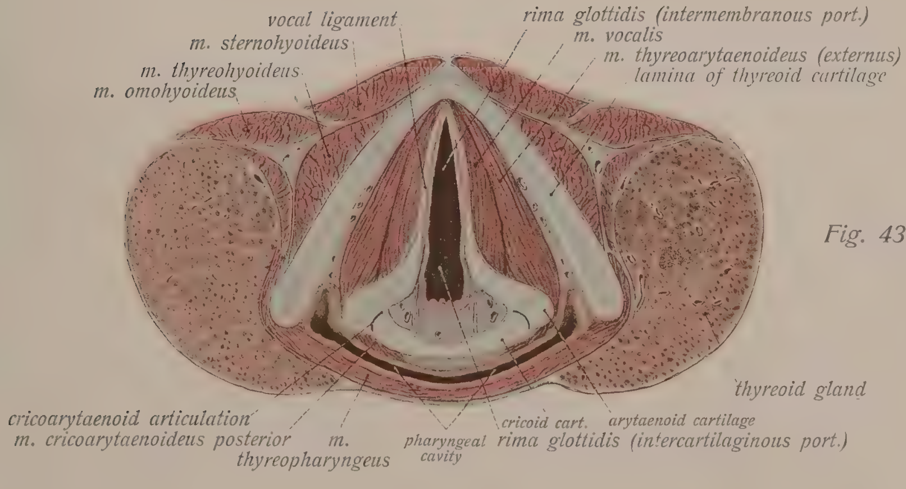

Fig. 437.

which take the place of the absent tips of the arytenoid cartilages. They produce the *corniculate tubercles* at the entrance of the larynx (Fig. 438).

The aryepiglottic folds (see page 97) near the anterior margins of the arytenoids usually contain the paired, rod-like, and flattened **cuneiform cartilages** (*cartilages of Wrisberg*). They correspond to the cuneiform tubercles of the aditus laryngis (Fig. 438).

The **cartilagines triticeæ** (Fig. 434) are very inconstant, rounded nodules of cartilage, which are occasionally found in the lateral hyothyreoid ligaments (see page 94).

The thyreoid, cricoid, and the greater portion of the arytenoid cartilages consist of hyaline cartilage; the epiglottic cartilage, the vocal process of the arytenoid, and the cartilages of Santorini and Wrisberg are made up of elastic cartilage.

Ossification of the thyreoid and cricoid cartilages occurs regularly in the male and frequently in the female. It begins at puberty and is extensive in the male subject only, usually being limited to the central portions of the cartilages.

The cartilages of the larynx are so arranged that the cricoid forms the foundation. Upon it are placed both the thyreoid and arytenoid cartilages, which are the chief constituents of the laryngeal skeleton. Of the remaining cartilages only those of Santorini and the epiglottis exhibit marked connections with the main portion of the skeleton, but they play no rôle in the mechanism of the laryngeal framework.

THE ARTICULATIONS AND LIGAMENTS OF THE LARYNX.

The laryngeal articulations (Figs. 433 to 439) are situated between the cricoid and thyreoid and between the cricoid and arytenoid cartilages. The remaining cartilages are either held together by (synchondroses or) syndesmoses or they have no actual connection with their fellows, the epiglottic cartilage, for example, being held in place by folds of its mucous membrane which pass to the thyreoid cartilage and to the tongue (see page 34).

The paired *cricothyreoid articulations* (Fig. 434) are the joints between the inferior cornua of the thyreoid and the arch of the cricoid cartilage. Functionally it is a kind of hinge-joint which is enclosed within a thin and lax *cricothyreoid articular capsule*. This capsule is reinforced by the *lateral* and *posterior ceratocricoid ligaments* (Figs. 433 and 434), which act partly as check ligaments, and anteriorly there is an *anterior ceratocricoid ligament* whose fibers interlace with those of the articular capsule. The thyreoid cartilage moves upon the cricoid in such a manner that it describes an arc of large radius around the cricoid; that is to say, in the forward and backward movement the upper extremity of the thyreoid cartilage moves through a greater arc than does the lower portion. The joints of the two sides always act together.

The paired *cricoarytenoid articulations* (Fig. 434) are the joints between the articular facets on the bases of the arytenoids and the arytenoid articular facets of the cricoid cartilage. Each of the thin *cricoarytenoid articular capsules* is reinforced posteriorly by a strong elastic *posterior cricoarytenoid ligament*, which passes inward from the internal surface of the arytenoid to the upper margin of the lamina of the cricoid cartilage. The mechanism of these joints is such that they always act simultaneously. When the arytenoid cartilages are at rest their internal surfaces are parallel and in the sagittal plane, and their vocal processes are consequently directed anteriorly. By the actions of the muscles upon the muscular processes, the tips of the vocal processes are

FIG. 438.—The aditus laryngis seen from behind and above.

FIG. 439.—The larynx opened from behind.
The left ventricular fold is drawn upward and the mucous membrane over the left vocal fold is divided.

FIG. 440.—The muscles of the posterior surface of the larynx.

FIG. 441.—The m. cricothyreoideus seen from the left side and somewhat from in front.

FIG. 442.—The muscles of the larynx seen from the left side.
The greater part of the left lamina of the thyreoid cartilage has been removed.

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either approximated (by turning the muscular processes anteriorly) or separated (by turning the muscular processes posteriorly).

The connection of each cartilage of Santorini with the arytenoid is termed the *arycorniculate synchondrosis*, but since the tissue connecting the cartilages is fibrocartilage, the articulation is really a syndesmosis.

In addition to the ligaments for the laryngeal articulations there is also a number of more or less independent ligaments, some of which, however, are simply portions of the elastic laryngeal lining.

The first of these is a lax elastic membrane, the *hyothyreoid membrane* (Figs. 433, 434, and 436), which passes from the upper margin of the thyreoid cartilage to the lower margin and greater cornua of the hyoid bone. It always presents a rounded opening (Fig. 433) which gives passage to the superior laryngeal nerve. The median firmer and tenser portion of the membrane is termed the *middle hyothyreoid ligament* (Fig. 433), in contradistinction to the lateral portions, which consist of marked fasciculi connecting the tips of the greater cornua of the hyoid bone with the superior cornua of the thyreoid cartilage and are termed the *lateral hyothyreoid ligaments*. Each of these latter structures frequently contains a *cartilago triticea*, usually situated at about the middle of the ligament. In front of the hyothyreoid membrane and immediately to either side of the middle hyothyreoid ligament there is constantly present a flattened lobulated mass of fat (Fig. 433), which is covered by the superficial fasciculi of the membrane.

In a similar manner the lower portion of the laryngeal skeleton, the cricoid cartilage, is connected with the trachea by the *cricotracheal ligament* (Fig. 433), which is inserted into the upper margin of the first tracheal ring. This ligament, which is rich in elastic fibers, seems to be the continuation of the elastic membrane of the larynx (see page 95).

A small ligament is found upon the posterior surfaces of the arytenoid cartilages. From the tip of each cartilage of Santorini an elastic fasciculus, the *corniculopharyngeal ligament* (Fig. 434), passes downward, and unites with its fellow of the opposite side to be attached to the upper margin of the lamina of the cricoid cartilage, in which situation it forms the *cricopharyngeal ligament*. As their names indicate, these ligaments are connected with the overlying pharyngeal mucous membrane.

The anterior surface of the epiglottis is attached to the upper margin of the body of the hyoid bone by the broad *hyoepiglottic ligament* (Fig. 436), which is rich in elastic fibers, while the petiole is connected to the superior thyreoid notch by the ligamentum *thyreoepiglottic ligament*. The glossoepiglottic folds, especially the middle one, also contain connective-tissue fasciculi which unite the epiglottic with the root of the tongue (see page 34).

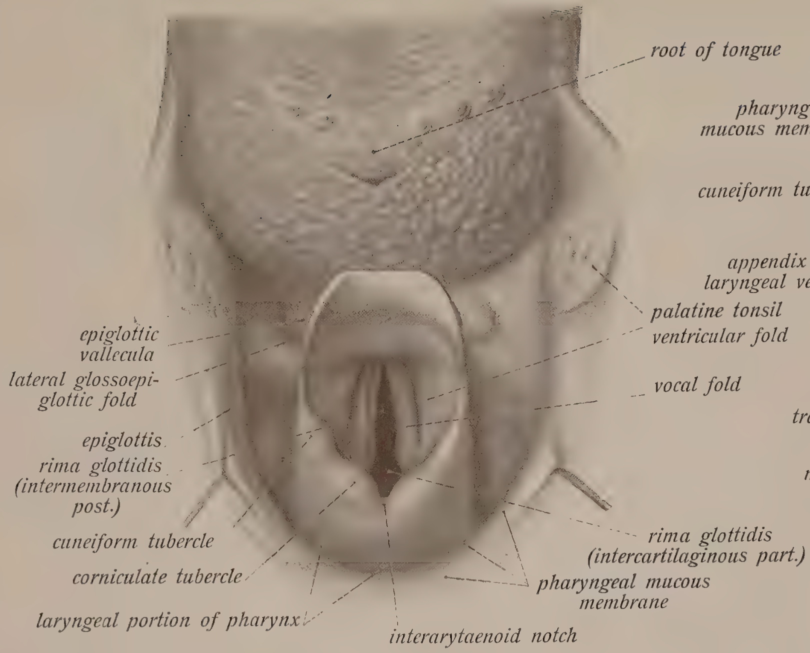

Fig. 438.

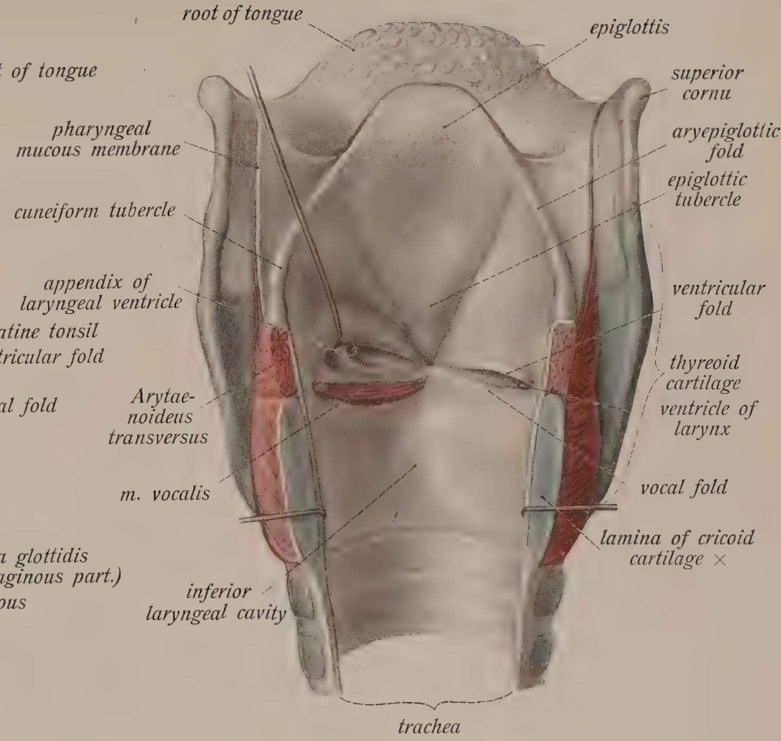

Fig. 439.

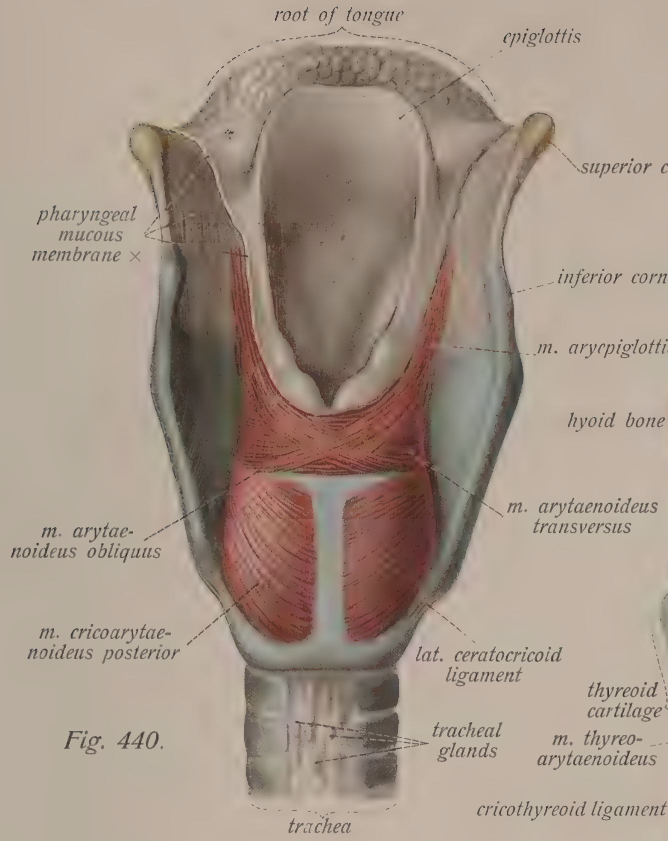

Fig. 440.

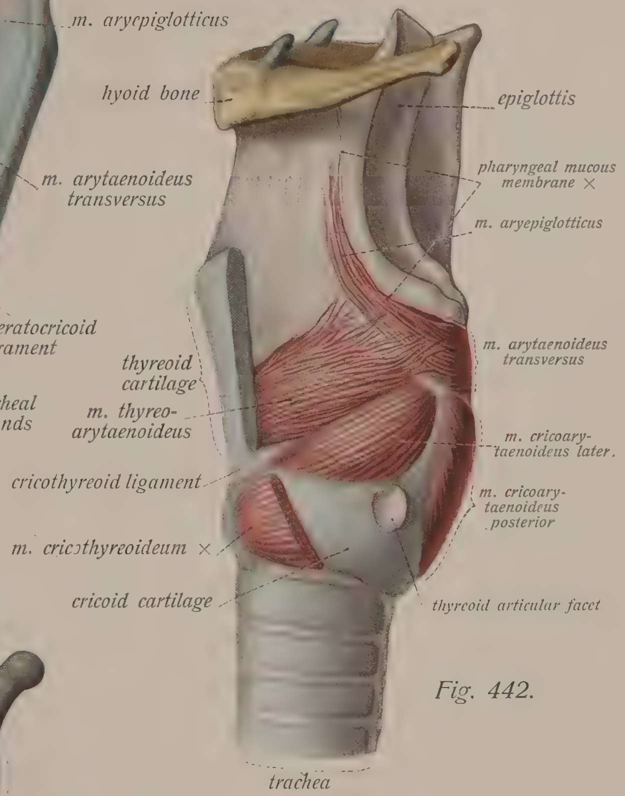

Fig. 442.

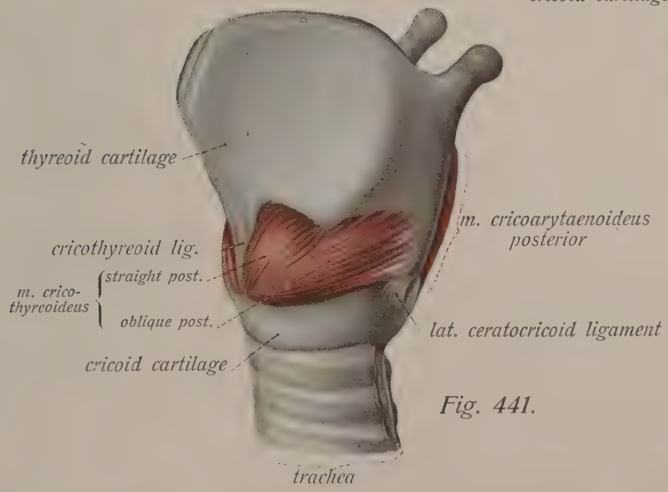

Fig. 441.

Upon the outer surface of the larynx there is a *cricothyreoid ligament* (lig. medium, conicum) (Fig. 433), a short strong elastic structure which frequently contains small foramina. It connects the inferior thyreoid notch with the upper margin of the arch of the cricoid and is the anterior extremity of the so-called elastic cone, and, consequently, not an independent ligament.

The *elastic cone* is a markedly developed portion of the elastic membrane of the larynx, which is situated immediately beneath the mucous membrane. It is a short conical tube, beginning at the upper margin of the cricoid cartilage and becoming narrower as it passes upward to the thyreoid and arytenoid cartilages, where it aids in the formation of the vocal cords and terminates abruptly at their upper margins. The cords, like the cricothyreoid ligament, are really portions of the elastic cone.

The *vocal ligaments* (Fig. 437) are paired thickened strips of the elastic cone, which arise close together from the inner surface of the angle of the thyreoid cartilage, and run parallel to one another, and close to the median plane, to the vocal processes of the arytenoid cartilages, which almost imperceptibly shade off into the pure elastic tissue of the ligaments.

The *ventricular ligaments* are weaker, less elastic, and longer structures which run parallel to the vocal ligaments. They arise immediately above the latter from the inner surface of the thyreoid angle, and pass to the anterior margins of the arytenoid cartilages above the attachments of the vocal ligaments.

THE LARYNGEAL MUSCLES.

The *cricothyreoideus* (Figs. 441 and 442) occurs upon either side of the anterior surface of the larynx and is partly covered by the sternothyreoideus and the thyreoid gland. It lies on either side of the middle cricothyreoid ligament and fills in the space between the lower margin of the thyreoid cartilage and the arch of the cricoid. Each muscle is composed of two portions which are not always distinctly separated, the straight and the oblique portion (Fig. 441). The former arises from the lower margin and anterior surface of the arch of the cricoid and passes almost vertically upward (really outward and upward) to the lower margin of the lamina of the thyreoid cartilage; it lies internal and superficial to the oblique portion, which it partly conceals, and is in contact with the cricothyreoid ligament. The oblique portion comes from the outer surface of the arch of the cricoid cartilage and passes obliquely outward and upward to the inferior cornu and the adjacent portion of the lamina of the thyreoid cartilage. Each constituent of the muscle is approximately triangular, so that the muscle as a whole is irregularly quadrangular.

The cricothyreoid is supplied by the superior laryngeal nerve (all the remaining laryngeal muscles are innervated by the inferior laryngeal nerve).

This muscle is the chief tensor of the vocal cords, since it increases the distance between the thyreoid and arytenoid cartilages, by approximating the lower border of the thyreoid and the arch of the cricoid and tilting backward the lamina of the cricoid.

The *cricoarytænoideus posterior* (Figs. 365 and 440), the strongest of all the laryngeal muscles, is situated upon the posterior surface of the organ. It is a paired muscle, almost triangular in shape, and arises from the shallow depression upon the posterior surface of the lamina of the cricoid cartilage, the muscles of the two sides being separated by the flattened median ridge of the cartilage. The muscle fibers converge toward the muscular process of the arytenoid, upon the posterior surface of which they are inserted.

The muscle is supplied by the inferior laryngeal nerve. Its chief function is the widening of the rima glottidis, which it effects by pulling the muscular process of the arytenoid backward (and downward); the arytenoid cartilage itself is thus rotated about its longitudinal axis so that the vocal process is turned outward (and upward).

The muscle sometimes gives off a fasciculus which is inserted into the inferior cornu of the thyreoid cartilage; it is known as the *ceratocricoideus*.

A second muscle, the *cricoarytænoideus lateralis* (Figs. 435 and 442), runs between the cricoid and arytenoid cartilages. It arises on either side from the upper margin of the arch of the cricoid and its short fibers pass obliquely upward, backward, and inward to the outer surface of the muscular process of the arytenoid cartilage.

This muscle is supplied by the inferior laryngeal nerve. It pulls the muscular process of the arytenoid downward, outward, and forward, and rotates the cartilage so that the vocal process is turned upward and inward. It consequently narrows the rima glottidis by approximating the two vocal processes.

The *arytænoidei* serve as sphincters of the aditus laryngis and are aided by several weaker and inconstant muscular fasciculi.

The single *arytænoideus transversus* (Figs. 440 and 442) is a short, thick, strong muscle of quadrangular shape. It runs from the outer margin and posterior surface of one arytenoid cartilage to the similar points upon the other, and fills out the fossæ (see page 92) upon the posterior surface of these structures.

The *arytænoideus obliquus* (Fig. 440) is a paired muscle, usually consisting of feebly developed fasciculi situated superficially to (behind) the transversus and crossing and interlacing in the median line. The fibers arise from the muscular process of one arytenoid and are inserted chiefly into the apex of the opposite cartilage; they are usually continued over the apex of the arytenoid into the aryepiglottic fold and extend as far as the lateral margin of the epiglottis. The latter fasciculi are also associated with independent fibers from the apex of the arytenoid or from the cartilage of Santorini and form what is termed the *aryepiglotticus* (Fig. 442). They are of variable development, as are also the other fibers passing to the epiglottis (see below).

All these muscles are supplied by the inferior laryngeal nerve and narrow the entrance to the larynx. The aryepiglotticus can also draw the epiglottis downward.

The thyreoid and arytenoid cartilages are connected with each other by a more or less continuous muscular mass which forms the musculature of the vocal cords. This may be regarded as consisting of three separate muscles, which, however, are usually intimately associated.

The *thyreoarytænoideus* (*externus*) (Figs. 437 and 442) arises from the inner surface of the lamina of the thyreoid cartilage and runs to the muscular process and the outer surface of the arytenoid cartilage. It is usually almost directly continuous with the outer margin of the m. vocalis. Individual muscular fasciculi, often very slightly developed, pass into the false vocal cord, where they run between the glands of this structure and the wall of the laryngeal ventricle and form what is termed the *m. ventricularis*. Other fibers frequently extend into the aryepiglottic folds, where they fuse with those of the aryepiglotticus; they are known as the *thyreoepiglotticus*.

The actual muscle of the vocal cord, the *m. vocalis* (Figs. 437 and 439), is adherent by its outer (upper) border with the thyreoarytænoideus and by its lower border with the (upper border of the) cricoarytænoideus lateralis. It is situated within the mucous membrane of the vocal fold,

arising from the inner surface of the lamina of the thyreoid cartilage close to the angle and inserting into the vocal process and the adjacent portion of the outer surface of the arytenoid. The muscle is intimately connected with the vocal ligament and, as it is shaped like a three-sided prism, it appears triangular in frontal section.

These muscles are also supplied by the inferior laryngeal nerve. Their function is the regulation of the finer movements and tension of the vocal cords. The thyreoarytænoideus narrows the rima glottidis, the vocalis shortens and consequently relaxes the true vocal cords, the ventricularis moves the false vocal cord, and the thyreoepiglotticus acts upon the epiglottis.

THE LARYNGEAL MUCOUS MEMBRANE.

Instead of a submucosa, the lining mucous membrane of the larynx possesses a strong layer of elastic fibers which forms the *elastic membrane of the larynx*. This becomes thicker in the lower portion of the larynx to form the *elastic cone*.

The mucous membrane of the larynx follows in general the relief of the laryngeal skeleton and of the elastic cone, but in certain situations it forms independent folds. It is directly continuous above with the mucous membrane of the mouth and pharynx and below with that of the trachea, but it is arbitrarily supposed to commence at the root of the tongue. In this situation it invests the upper and anterior surface of the epiglottis and is attached to the tongue by three folds, the *median* and two *lateral glossoepiglottic folds* (Fig. 351). Between them upon either side is a depression, the *epiglottic vallecula*. Two other folds, the *aryepiglottic folds* (Figs. 436 and 439), pass from the epiglottis to the apices of the arytenoids or to the cartilages of Santorini. They form the lateral boundaries of the entrance to the larynx (*aditus laryngis*), and, in addition to muscular fibers (aryepiglotticus), usually contain the cartilages of Wrisberg. The aditus laryngis (Fig. 438) is situated upon the anterior wall of the upper portion of the laryngeal portion of the pharynx and corresponds to the level of the fourth cervical vertebra. It is bounded anteriorly by the epiglottis, laterally by the aryepiglottic folds, and posteriorly by the arytenoids and cartilages of Santorini. Between the cartilages of the two sides, the laryngeal mucous membrane forms the *interarytænoid fold*, which partly rounds off the *interarytænoid notch*, situated between the two arytenoids.

At the posterior portion of the aditus laryngis are two nodular elevations of the mucous membrane (Fig. 438): (1) the *corniculate tubercle*, corresponding to the location of the cartilage of Santorini; and (2) the *cuneiform tubercle*, corresponding to the cartilage of Wrisberg.

From the aditus laryngis the mucous membrane extends into the interior of the organ and lines the laryngeal cavity, the most important structure which it produces in this situation being the vocal apparatus or *glottis*. This divides the laryngeal cavity into two chief portions, the *laryngeal vestibule*, situated above the glottis and below the aditus, and the *laryngeal cavity*, which lies below the glottis.

The *glottis* is placed somewhat below the center of the larynx and consists of two lips, the *labia vocalia*, and of a median fissure, the *rima glottidis* (Fig. 438). Each lip is formed by the mucous membrane investing the vocal ligament and the m. vocalis (Fig. 437), and its free margin is called the *vocal fold* (true vocal cord), which in its posterior portion contains the vocal process of the arytenoid cartilage (Fig. 436).

The *rima glottidis* (Fig. 438) consists of a short posterior portion, the *intercartilaginous*

portion, *i. e.*, the portion bounded by the vocal processes of the arytenoids with their investment of mucous membrane, and the *intermembranous portion*, the longer anterior portion between the vocal ligaments and their mucous covering. The intercartilaginous portion is the wider, the intermembranous the narrower portion. In their relaxed condition in the cadaver both portions may always be distinctly recognized, since the tip of the vocal process is visible as a yellowish point beneath the mucous membrane. Another yellowish spot, known as the *macula flava*, is constantly present at the anterior extremity of the labia vocalia, where the elastic fibers of the vocal ligament are particularly dense. The labia vocalia project markedly toward the median line and the rima glottidis is consequently the narrowest portion of the laryngeal cavity.

Upon the anterior wall of the vestibule of the larynx is situated a nodule, the *epiglottic tubercle* (Fig. 439), which corresponds to the base of the epiglottic petiole. Above and parallel to the true vocal cords are found two folds of mucous membrane, known as the *ventricular folds* or *false vocal cords* (Figs. 435, 436, and 439); they contain the ventricular ligaments (and muscles). Between their free internal edges is situated a fissure, the *rima vestibuli*, which is considerably wider than the rima glottidis, so that when the larynx is viewed from above (through the aditus laryngis), the true vocal cords are seen in the rima ventricularis (laryngoscopic picture). Below the false and above the true cords is situated a lateral recess of the laryngeal cavity which is known as the *ventricle of the larynx* (*ventricle of Morgagni*) (Figs. 435, 436, and 439). From its upper wall a blind process of variable development extends upward upon the posterior surface of the lamina of the thyreoid cartilage, behind the anterior extremity of the false vocal cord, and is known as the *appendix* of the ventricle (Fig. 439). In many of the anthropoid apes this forms the so-called laryngeal sac. The lower portion of the ventricle of the larynx is called the *aditus glottidis superior*.

Below the glottis the mucous membrane covers smoothly the inner surface of the elastic cone and exhibits no folds, since it is firmly connected with the elastic tissue, the cavity of this portion of the larynx exactly corresponding to the shape of the cone. The portion situated below the glottis is called the *aditus glottidis inferior*.

Except upon the vocal cords, a large number of mucous glands are situated in or beneath the laryngeal mucous membrane and are termed the *anterior*, *middle*, and *posterior laryngeal glands*.

The larynx of the female differs from that of the male in the smaller size of the cartilages as well as by its smaller dimensions in general, and, in addition, the laminæ of the thyreoid are united at an obtuse instead of at a right angle, as in the male. During childhood the larynx of both sexes is of the female type, but in the male it commences to grow quite rapidly at the age of puberty. In the female the cartilages usually remain cartilaginous and never undergo more than a trivial ossification.

The arteries of the larynx are the superior laryngeal branch of the superior thyreoid and the inferior laryngeal branch of the inferior thyreoid. The veins are named like the arteries; the superior empties into the superior thyreoid vein, which passes to the internal jugular, the inferior runs to the plexus thyreoideus impar and to the left innominate vein.

The lymphatics pass chiefly to the superior deep cervical lymphatic glands.

The nerves are the superior and inferior laryngeal, both of which are branches of the vagus, although their

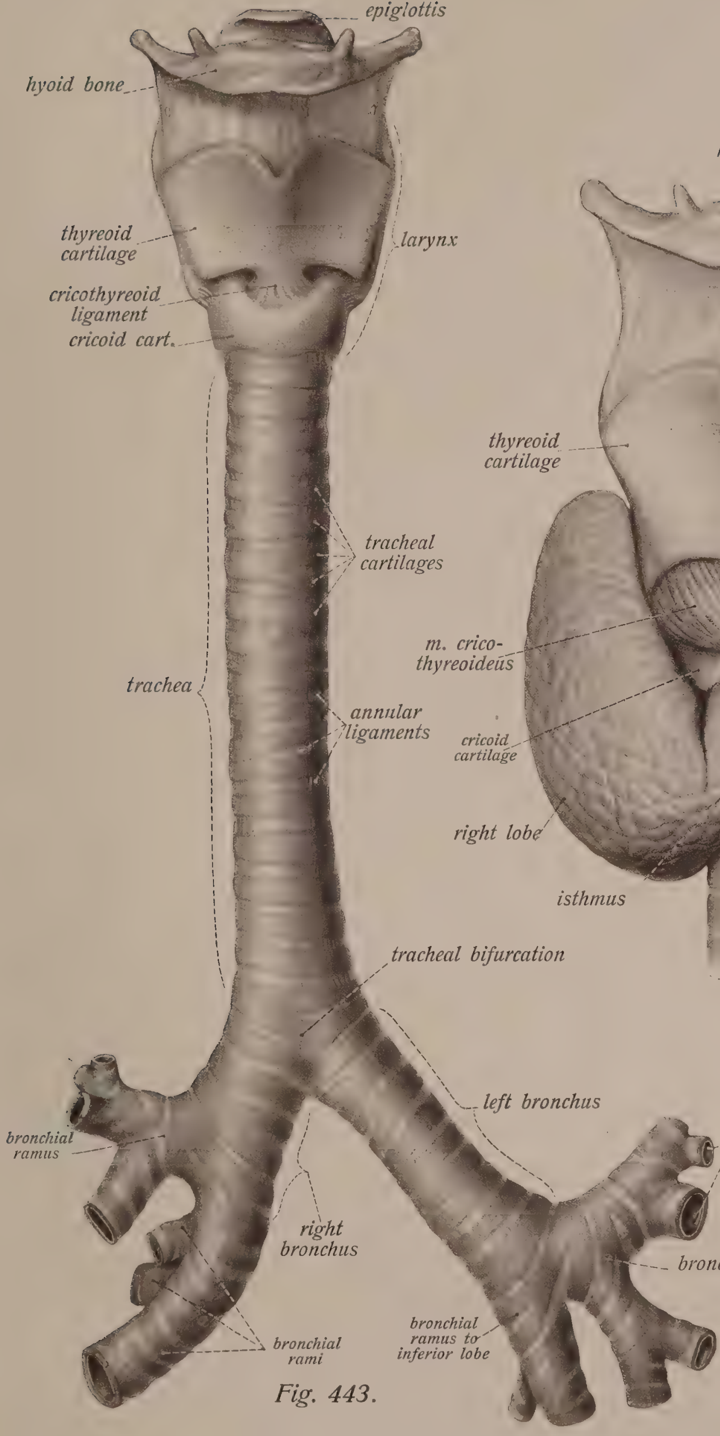

Fig. 443.

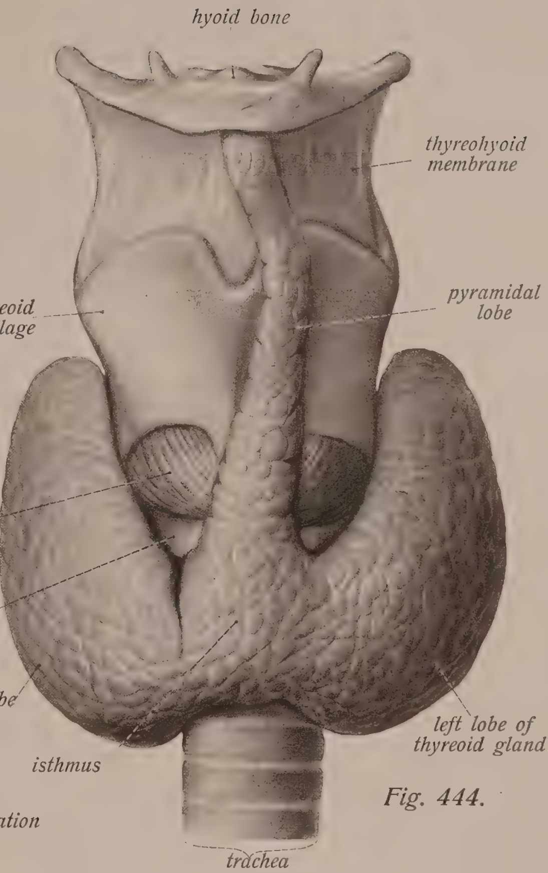

Fig. 444.

origins are widely separated. The superior laryngeal is largely the nerve of the mucous membrane, but its external branch also supplies the cricothyreoideus; the inferior laryngeal is largely motor and supplies the remaining laryngeal muscles.

THE TRACHEA AND ITS DIRECT RAMIFICATIONS, THE BRONCHI.

The **trachea** (Figs. 328 and 443) is a rather rigid and constantly open tube, 10 to 12 cm. long and 11 to 18 mm. wide, which leaves the larynx at the level of the intervertebral disc between the sixth and seventh cervical vertebræ and extends to that of the disc between the fourth and fifth thoracic vertebræ. In the latter situation or in front of the fifth thoracic vertebra it divides into two branches, the *bronchi*, which form a right angle with each other. This division is called the *tracheal bifurcation*.

Throughout its entire length the trachea is situated almost in the median line, the larger portion being in the neck and the smaller in the thorax.

In the neck it lies in the thyreoid and suprasternal regions and in the jugular fossa, and its anterolateral portion is covered by muscles (sternohyoideus and sternothyreoideus). Near the median line its anterior wall is separated from the skin only by the superficial layer of the deep cervical fascia, except where it is crossed by the isthmus of the thyreoid gland, but toward the sternum it gradually assumes a deeper position, and in the lower portion of the neck, it is placed behind the thyreoid venous plexus and the vena thyreoidea ima.*

The thoracic portion of the trachea lies behind the manubrium sterni and the left innominate vein, other structures in front of it in this situation being the innominate artery, which crosses it at an acute angle, and a part of the left common carotid (lateral wall of the trachea). The tracheal bifurcation is situated immediately behind the aortic arch, and the entire length of the posterior (membranous) wall of the trachea is in immediate contact with the œsophagus (see page 44) (Fig. 459).

The tracheal skeleton consists of cartilaginous rings, the *tracheal cartilages*, which are open posteriorly, where from a third to a fifth of their circumference is wanting. Their number varies between sixteen and twenty, and they form the anterior and lateral walls of the trachea, which are cylindrical, while the posterior wall is flattened. The rings frequently bifurcate (the lower more often than the upper) or neighboring rings anastomose with each other; in rare instances they are perforated. Their posterior extremities have markedly rounded apices and are of about the same width as the remaining portion of the ring. The uppermost ring is the widest and is never bifurcated; it is connected with the inferior margin of the cricoid cartilage by the cricotracheal ligament (see page 94), and the remaining cartilages are connected with each other by elastic membranes, the *annular ligaments*, which pass from the inferior margin of one cartilage to the superior margin of the underlying one, each margin usually being slightly beveled.

The posterior wall of the trachea has no cartilaginous skeleton and is consequently called the *membranous wall*. It is flattened and consists chiefly of nonstriated muscular tissue which is stretched between the extremities of the tracheal rings.

The mucous membrane of the trachea is a direct continuation of that of the larynx and exhibits the same characteristics. It rests upon a thick elastic foundation, the continuation of

* In rare cases also behind the inconstant arteria thyreoidea ima.

FIG. 445.—Lateral surface of the right lung.

FIG. 446.—Lateral surface of the left lung.
*= Tongue-like process of the lung which rests upon the pericardium.

FIG. 447.—Median surface of the left lung.
*= Tongue-like process of the lung which rests upon the pericardium.

FIG. 448.—Median surface of the right lung.

FIG. 449.—The two lungs from in front, together with the lower part of the trachea and the bronchi, the branches of the bronchi being exposed by cutting away the lung tissue.

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the elastic membrane of the larynx, which contains marked longitudinal fasciculi. The mucous tracheal glands are particularly plentiful in the region of the annular ligaments and of the membranous wall (Fig. 440), and in the latter situation the large glands usually extend through the musculature and are visible upon the outer surface of the trachea as nodules the size of a millet-seed.

The two **bronchi** (Figs. 443, 449, and 450) arise at the tracheal bifurcation, the right bronchus being shorter and broader than the left. As they leave the bifurcation they make almost a right angle with each other, and each passes outward and downward to the hilus of the lung, where it subdivides into its ramifications. At the tracheal bifurcation a few bronchial lymphatic glands are not infrequently present.

The structure of the walls of the bronchi almost completely corresponds with that of the trachea. They are similarly provided with incomplete cartilaginous rings and possess a posterior membranous wall with bronchial glands. The shape of the cartilaginous rings is more irregular in the bronchi than in the trachea, and anastomoses between them are more frequent. At the bifurcation there is sometimes a single common cartilage which is connected with the last tracheal ring (Fig. 443).

The cervical trachea is supplied with blood by the inferior thyreoid, the thoracic trachea by the bronchial arteries. In the neck the veins empty into the inferior or middle thyreoid veins or into the thyreoid plexus. The lymphatics pass to the tracheal and bronchial lymphatic glands, and the nerves are furnished partly by the vagus and partly by the sympathetic.

THE LUNGS (PULMONES).

The lungs (Figs. 445 to 449, 451, and 452) are paired viscera which according to their mode of development (see page 105) are to be regarded as glands. The right and the left lung are similar, but not exactly alike, the right lung being more voluminous than the left, the inequality being essentially due to the displacement of the heart toward the left (see page 171).

With the exception of a median space, the *mediastinum* (see page 109), which is practically taken up by the heart, the lungs fill the thoracic cavity, their general conical shape* accurately corresponding to that of the thorax and to the convexity of the dome of the diaphragm.

The *base* of the lung (Figs. 447 to 449) is markedly concave, and its surface, resting upon the dome of the diaphragm, is known as the *diaphragmatic surface.* The *apex* of each lung is directed upward, being situated in the superior thoracic aperture, and its internal surface exhibits a rather

* The shape of each lung may more accurately be said to resemble that of a longitudinal hemisection of a cone.

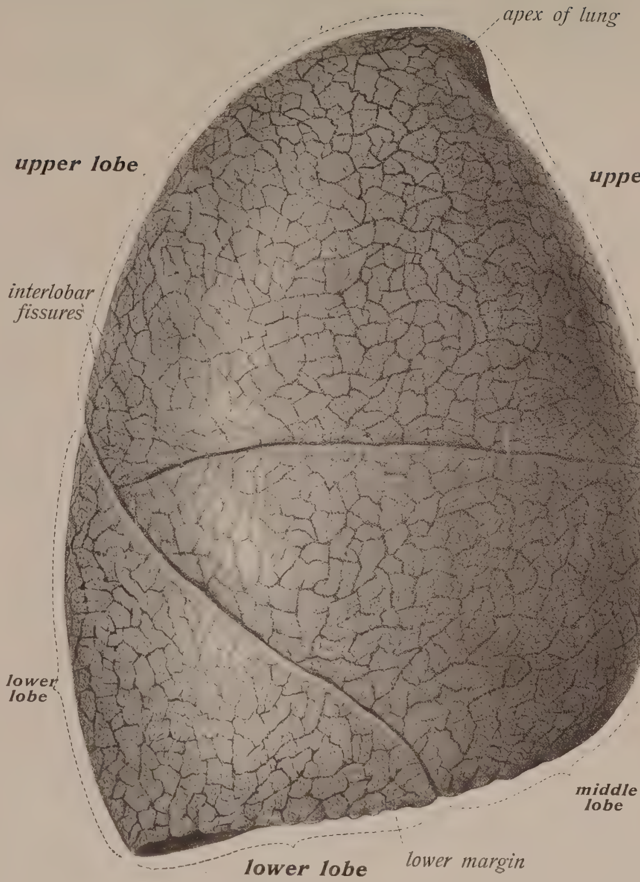


Fig. 445.

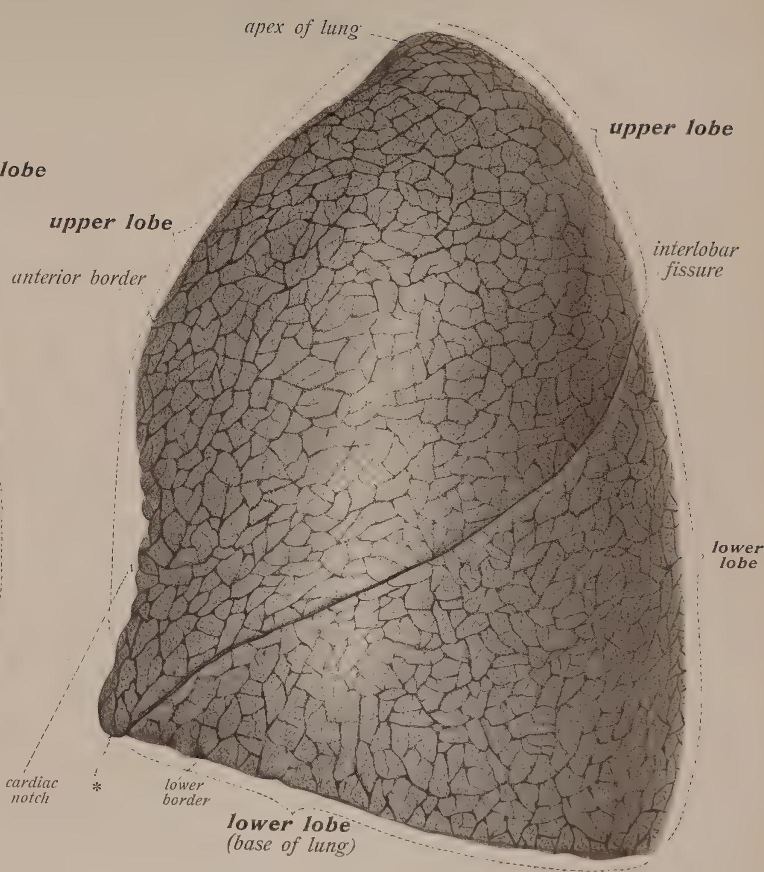


Fig. 446.

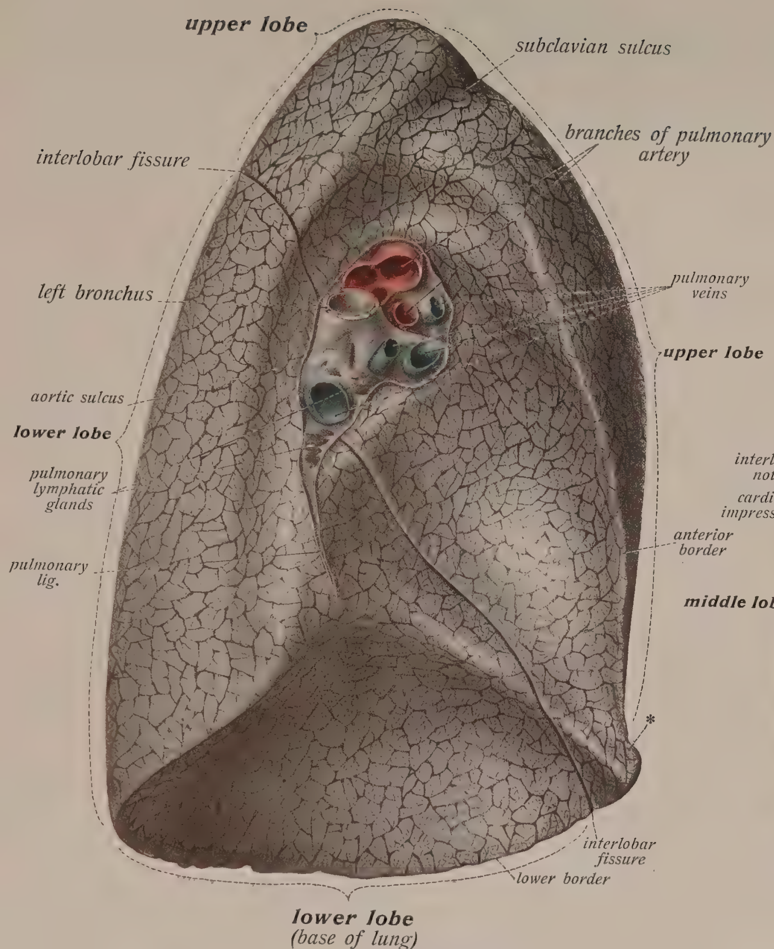


Fig. 447.

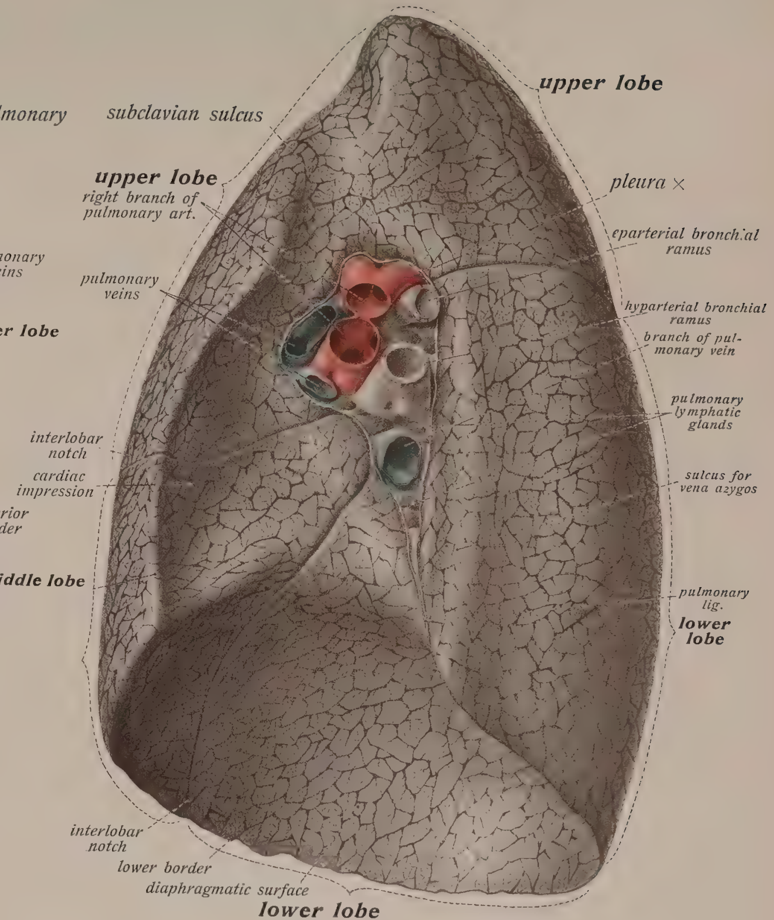
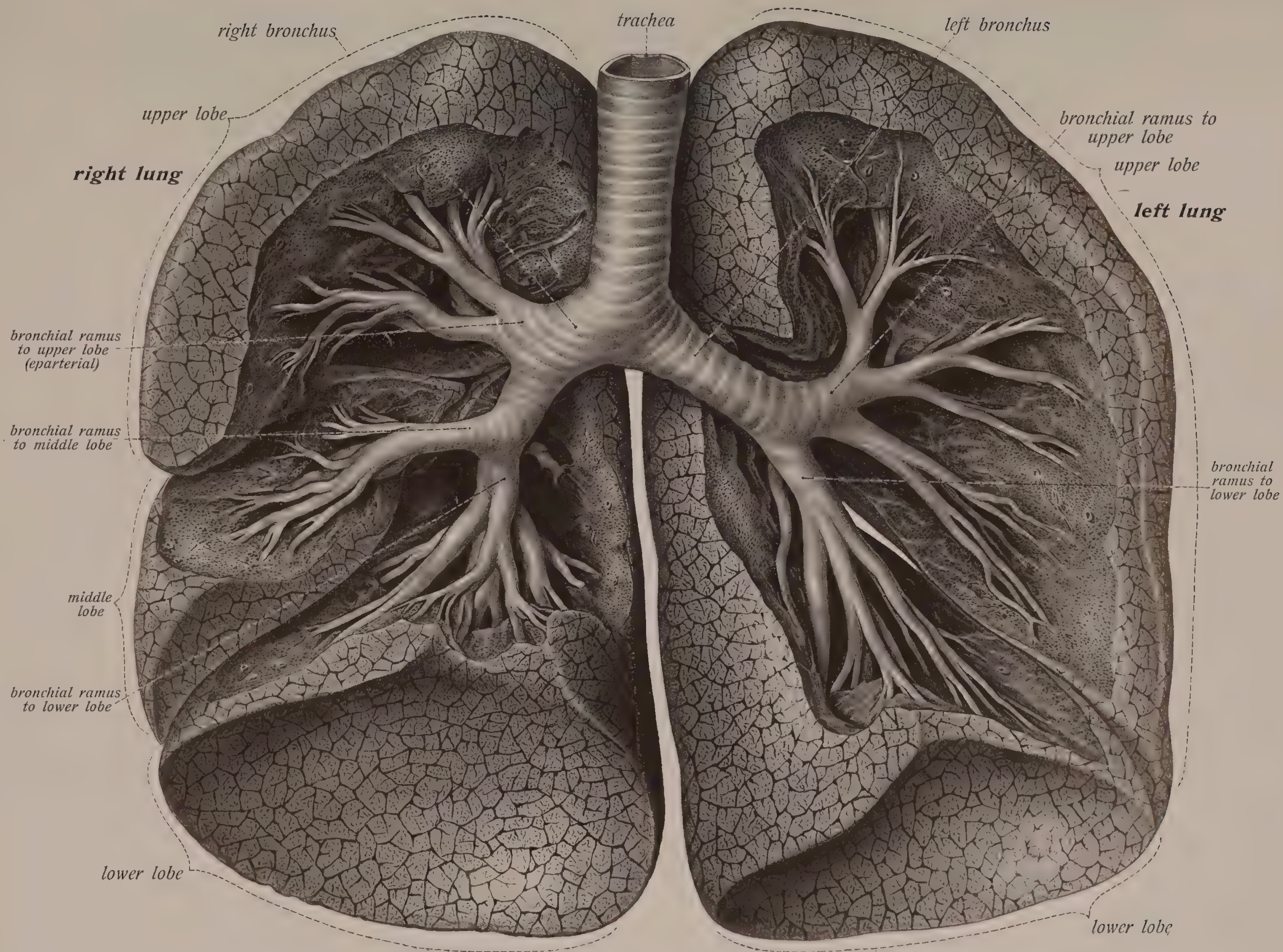


Fig. 448.



trachea
right bronchus
left bronchus
upper lobe
right lung
bronchial ramus to upper lobe
upper lobe
left lung
bronchial ramus to upper lobe (eparterial)
bronchial ramus to middle lobe
bronchial ramus to lower lobe
middle lobe
bronchial ramus to lower lobe
lower lobe
lower lobe

Fig. 449.

broad shallow furrow, the *subclavian sulcus* (Figs. 447 and 448), which is produced by the subclavian artery.

The extensive convex surface (Figs. 445 and 446), which is directed chiefly outward and is in contact with the thoracic wall, is termed the *costal surface,* while the opposite, much smaller, largely concave, internal surface is directed toward the heart and is known as the *mediastinal surface.*

The costal and diaphragmatic surfaces are separated by the sharp lower border; the

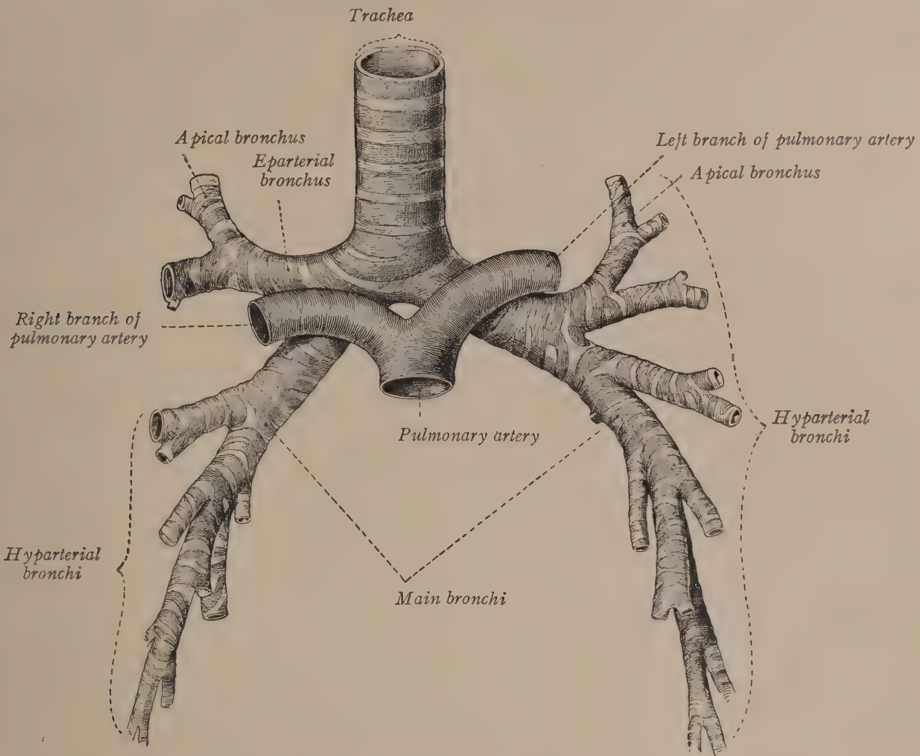


FIG. 450.—Diagram of the relation of the bronchi to the pulmonary arteries, seen from in front.

mediastinal and costal surfaces are separated in front by the anterior border, which is neither so sharp, regular, nor smooth, but is nevertheless very thin.

The mediastinal surface (Figs. 447 and 448) is situated approximately in the sagittal plane and is concave only in the middle and toward the anterior margin, the concavity corresponding to the surface of the heart and being termed the *cardiac impression.* As a result of the unsymmetrical position of the heart, the surface is larger in the left than in the right lung. That portion of it which lies behind the cardiac impression is convex and exhibits a vertical groove, produced by the aorta in the left lung, where it is consequently broad and deep, and by the vena azygos

in the right lung, where it is correspondingly narrow and shallow. In the region of the apex this surface also presents the subclavian sulcus.

The posterior portion of the cardiac impression contains a slightly depressed pear-shaped area, whose apex is directed downward; this area is uncovered by the pleura and is the *hilus* of the lung. It is for the entrance of the vessels and bronchi, which form the so-called *root* of the lung.

With the exception of the hilus, almost the entire surface of the lung is covered by the pleura and is consequently perfectly smooth. Through this membrane may be seen the reddish-gray pulmonary substance upon which the limits of the individual pulmonary lobules may be recognized as dark bluish-black or black lines which are due to the accumulation of coal-dust in the interstitial tissue. They form irregular pentagonal or hexagonal, slightly elevated areas, which correspond to the pulmonary lobules, and from them finer lines are sometimes given off. Usually additional rounded pigmented areas are also observable, which vary in size, but rarely exceed several millimeters in diameter. Each lung possesses deep fissures passing from the surface to the interior of the organ; they are known as the *interlobar fissures* or *notches* and mark off the individual pulmonary lobes, penetrating deeply into the pulmonary substance. The pleura extends to the bottom of the fissures.

The pulmonary tissue is spongy in character and is frothy upon cross-section on account of the admixture of air-bubbles from the alveoli with the blood from the divided vessels and the bronchial mucus.

The larger right lung is subdivided by two interlobar fissures into three lobes which are known as the *upper*, *middle*, and *lower lobes;* the smaller left lung has but a single fissure and two lobes, an *upper* and a *lower*. The interlobar fissure of the left lung begins above at the level of the third rib and passes obliquely from behind forward and above downward, to terminate upon the base of the lung, so that the anterior portion of the lower border is included in the upper lobe (Fig. 446). This fissure is visible upon the costal surface, the mediastinal surface (except at the hilus), and to a limited extent also upon the diaphragmatic surface.

The interlobar fissure of the right lung, which separates the superior from the middle and inferior lobes, corresponds to the interlobar fissure of the left lung, except that it commences somewhat lower posteriorly and terminates further externally at the base and inferior margin than is the case in the left lung (Figs. 446 and 448). It is considerably deeper than the second fissure, and is visible upon the costal surface, the mediastinal surface (anterior and posterior portions), and the diaphragmatic surface. The second interlobar fissure of the right lung, is shorter and shallower than the first and is subject to considerable variation in its development. It separates the middle from the upper lobe and is placed approximately at a right angle with the other fissure. It is visible only upon the costal surface and that portion of the mediastinal surface which is situated in front of the hilus, and does not appear upon the diaphragmatic surface. The upper lobe of the right lung consequently does not extend to the pulmonary base, as is the case upon the left side. The middle lobe of the right lung is by far the smallest of the three.

In addition to the number of lobes, the right and left lungs exhibit still other differences. The left lung is narrower and somewhat longer than the right, since it extends to a somewhat lower level, but the apex of the much broader but shorter right lung usually reaches somewhat

higher than does that of the left. The volume of the right lung is about one-tenth greater than that of the left. The anterior margin of the right lung is almost straight, but that of the left presents a notch, the *cardiac notch* (Fig. 446), through which the pericardium is visible, and below which the antero-inferior extremity of the upper lobe extends as a narrow tongue-like lobe in front of the pericardium.

In addition to the hilus there is a narrow strip of the lung, extending downward from the apex of the hilus, which is uncovered by pleura; it gives attachment to the pulmonary ligament (see page 112). In the left lung (Fig. 447) this strip is situated immediately in front of the groove produced by the aorta; in the right, in front of that caused by the vena azygos. In addition to the vessels and bronchi forming the root of the lung, the hilus also contains the small pulmonary lymphatic glands, which rarely attain a size larger than that of a pea. The vessels and bronchi entering the hilus are arranged in such a manner that the branches of the pulmonary artery are the most superior, those of the pulmonary vein most anterior, and the bronchi most posterior.

Each lung lies in a serous sac formed by the pleura, and during inspiration almost entirely fills the thoracic cavity. They are in relation chiefly with the heart and the large vessels which make impressions upon their surface, and they are separated from the liver, stomach, and spleen by the diaphragm.

In relation to the skeleton, the left lung usually extends somewhat further downward than the right (Figs. 451 and 452). While by far the greater portion of each lung is situated within the thoracic cavity (see Vol. I, page 32), the pulmonary apices extend above the clavicles and the superior thoracic aperture by about 3 or 4 cm. and correspond to about the level of the neck of the first rib. The lateral pulmonary limits are defined by the shape of the thorax. In moderate expiration the lower pulmonary border corresponds to the sixth rib in the parasternal and mammillary lines,* to the upper margin of the eighth rib in the axillary line (the lower margin of the left lung extends to the eighth intercostal space), to the ninth or tenth rib in the scapular line, and to the tenth or eleventh thoracic vertebra in the median line (in this situation the left lung extends to the eleventh rib). The anterior border of each lung is situated superiorly behind the sterno-clavicular articulation, and upon the right side it extends in a straight or slightly curved line to the sixth rib; while upon the left it passes downward to the fourth costal cartilage, below which it is continuous toward the left with the cardiac notch.

Before the bronchi reach the pulmonary hilus they subdivide into their branches, which are known as the *bronchial rami*. According to their relation to the branches of the pulmonary artery at the pulmonary hilus, *eparterial* and *hyparterial bronchi* may be recognized (Figs. 447, 448, and 450). The ramus passing to the upper lobe of the right lung is the only one which is eparterial, *i. e.*, it enters the lung above the branches of the pulmonary artery; the remaining bronchial rami of the right lung, as well as all of those of the left, are hyparterial.

The bronchus which traverses the entire lung, gradually becoming smaller in caliber as it

* Since the ribs are not placed horizontally but obliquely, the location of a thoracic organ is determined by a number of lines: the *sternal line* is at the lateral margin of the sternum parallel to the median line; the *mammillary line* is parallel to the preceding and passes through the nipple; the *parasternal line* is midway between the sternal and mammillary lines; the *axillary line* passes through the center of the axillary cavity and proceeds from its highest point; and the *scapular line* is parallel to the median line and passes through the inferior angle of the scapula.

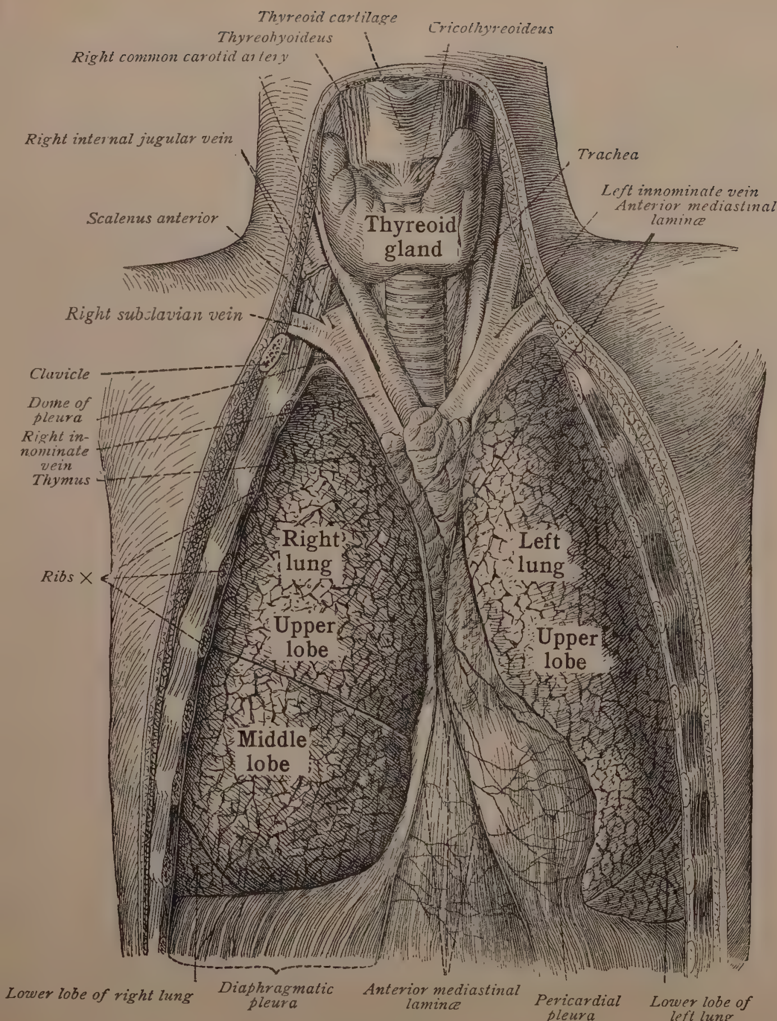


Fig. 451 *a*.

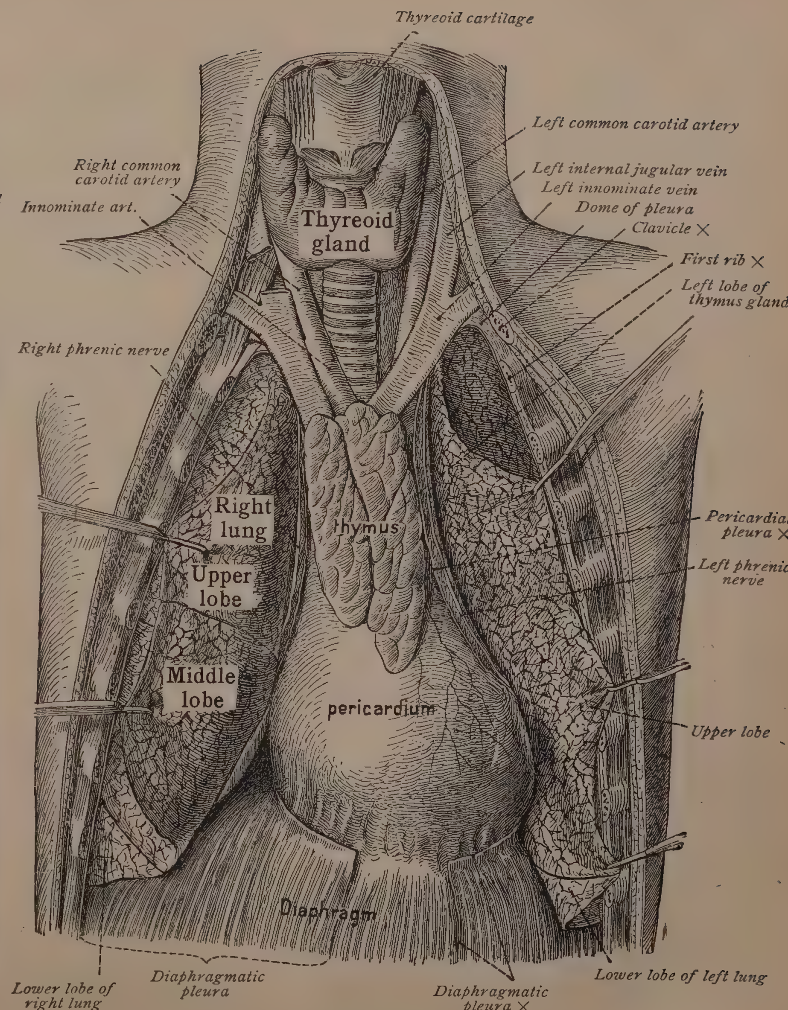


Fig. 452 *a*.

FIGS. 451 AND 451 *a*.—The thoracic viscera of an eight-year-old boy seen from in front after removal of the sternum and the anterior ends of the ribs. The mediastinal pleura has been cut close to its attachment to the sternum; in the neck the thyreoid gland and some of the large vessels have been exposed.

FIGS. 452 AND 452 *a*.—The same preparation as the preceding, except that the lungs have been drawn outward so as to show the pericardium and the thymus. The pericardial pleura has been partly dissected off from the pericardium.

Fig. 451.

Fig. 452.

pursues a slightly curved course toward the posterior portion of the base, is designated as the *main bronchus* (Fig. 450), and seems to be the direct continuation of the bronchus given off from the tracheal bifurcation. Running off at an acute angle from this are small dorsal and larger ventral lateral ramifications, which pursue a slightly curved course, the concavity of which is directed downward. Only the uppermost branch of each main bronchus, known as the apical bronchus, passes in a curved direction with the convexity downward; upon the right side it runs to the upper lobe, upon the left to the upper portion of the upper lobe. The right apical bronchus is eparterial, but the left, like all the bronchi upon this side, is hyparterial.

Unlike the trachea and its two bronchi, the bronchial ramifications are cylindrical, since the membranous wall is absent, and instead of cartilaginous rings they contain cartilaginous plates of irregular shape, which extend about their entire circumference. These plates are frequently perforated and become smaller and smaller as the bronchial ramifications penetrate into the pulmonary tissue; they disappear entirely when the caliber of the bronchioles becomes less than one millimeter.

(For further details in reference to these structures as well as to the lung in general see the Sobotta-Huber "Atlas and Epitome of Normal Histology.")

Two different arteries enter the lung. The main vessel is the pulmonary artery, the artery of the lesser or pulmonic circulation (see page 167). Each lung receives a branch of the pulmonary artery, which in turn gives off smaller branches at the pulmonary hilus. The pulmonary artery brings the blood which has been utilized in the general circulation (the so-called venous blood) to the lung, and the blood which has been oxygenated or "arterialized" in the lung leaves the viscus through the pulmonary veins. The venous branches leaving each lung are usually collected by two main trunks at each hilus.

The branches of the pulmonary artery entering each hilus are accompanied by small branches of the aorta, the bronchial arteries. They supply the walls of the bronchial ramifications; their capillaries or venous radicals are apparently inconstant in their termination, some of them passing into the vena azygos. The numerous lymphatic vessels of the lungs pass first to the pulmonary lymphatic glands situated in the neighborhood of the hilus, and from these to the higher bronchial lymphatic glands (see page 100). Very small lymphatic glands are also situated beneath the visceral pleura. The nerves of the lung are furnished by the vagus, which gives off numerous small trunks entering the hilus, and by the sympathetic.

The lungs and the entire respiratory tract are developed as a diverticulum from the embryonic foregut. This diverticulum is visible as a blind pocket in the third week of embryonic life, but this soon enlarges and exhibits indications of the subsequent larynx, trachea, and lungs. The diverticulum becomes constricted from what is subsequently the pharynx at the site of the aditus laryngis, and at the end of the fourth week of embryonic life the blind extremity of the respiratory diverticulum divides, and indicates the position of both lungs, which subsequently develop exactly like glands by a process of budding or sprouting.

THE THYREOID GLAND.

The thyreoid gland (Figs. 444, 451, and 452) has only topographic relations to the organs of the respiratory tract; in other respects it belongs to the ductless glands (glands with internal secretions). It is situated in the neck in front of the trachea and the lateral portions of the larynx, and is also partly in contact with the lateral wall of the laryngopharynx. Its middle portion is covered by the superficial layer of the deep cervical fascia, and laterally it is immediately beneath the sternothyreoidei, which lie upon the gland, the remaining infrahyoid muscles, the inner margin of the sternocleidomastoideus, and the platysma.

The gland has a yellowish-red color and a rather smooth surface; it is shaped like a horse-

shoe and is of moderately firm consistence. It is a single structure, consisting of a narrow middle portion or *isthmus* and of two lateral *lobes*. Its size is subject to great individual variations and it frequently attains considerable dimensions as a goitre.

The *isthmus* (Fig. 444) is a markedly flattened cylindrical body situated in front of the upper three or four tracheal rings, although when markedly developed it may also lie in front of the cricotracheal membrane and the arch of the cricoid cartilage; it is connected to these structures by loose connective tissue. Corresponding to the shape of the trachea, the isthmus of the gland is convex anteriorly and concave posteriorly. A single elongated and pointed lobe not infrequently proceeds upward from the isthmus and is known as the *pyramidal lobe* (Fig. 444); it is situated in front of the thyreoid cartilage, in the median line or to one side (usually to the left) of it, and extends upward as far as the body of the hyoid bone. In this situation flat fasciculi of non-striated muscle fibers occur which connect the isthmus with the thyreoid cartilage or the hyoid bone and are known as the *levator glandulæ thyreoideæ.*

The lateral *lobes* of the thyreoid gland extend upward and backward; they lie upon the lateral portions of the laminæ of the thyreoid cartilage and their margins extend to the lateral pharyngeal walls. They are more voluminous and thicker than the isthmus, and their height is about twice their breadth; they are irregularly ellipsoidal in shape, their lateral surfaces being markedly convex and their internal ones somewhat flattened.

The thyreoid gland is surrounded by a fibrous capsule which is also attached to the tracheal skeleton (suspensory ligaments of the thyreoid gland), and within this capsule the individual lobules of the gland are separated from each other by fasciculi of connective tissue. According to their degree of distention with their secretion of colloid material they appear upon cross-section as vesicles of varying size.

One or two pairs of small *accessory thyreoid glands* (*parathyreoids*) occur on the posterior surface of the lobes, and the isthmus, or still more often the pyramidal lobe, may appear as an accessory gland, since the connections of either of these structures with the lateral lobes may be lost. Indeed, both of these portions of the gland are subject to great individual variation. In addition another pair of small accessory thyreoids (parathyreoids) occur rather constantly at the lower margins of the lateral lobes beside the inferior thyreoid artery, and are about the size of a lentil. The median suprahyoid accessory thyreoid, which is a single structure situated above the body of the hyoid bone, may be regarded as an incompletely developed pyramidal lobe.

The thyreoid gland receives four large arteries, the superior thyreoids from the external carotids and the larger inferior thyreoids from the subclavians. In rare instances they receive a fifth artery, the thyreoidea ima. The superior thyreoid veins pass to the internal jugular, and the inferior thyreoid veins form the plexus thyreoideus impar, which is situated at the lower margin of the gland and empties by means of the vena thyreoidea ima and other vessels into the left innominate vein. The lymphatics of the thyreoid gland are very numerous; some pass to the small lymphatic glands in the immediate vicinity, some to the inferior deep cervical lymphatic glands, and others (from the isthmus) empty into the anterior mediastinal glands.

The thyreoid gland is developed from three rudiments, one single and two paired. The former arises as a diverticulum behind the tuberculum impar (see page 37), and during the development of the tongue it gradually becomes constricted from its connection, so that the original excretory duct, the *ductus thyreoglossus*, is obliterated up to the foramen cæcum and the lingual duct (see page 34). [This median forerunner of the thyreoid gives rise to the isthmus and lobes of the gland and is joined by paired lateral diverticula from the epithelium of the fourth pair of pharyngeal pouches which form the parathyreoids, the lower parathyreoids being formed from similar diverticula from the third pair of pouches.—Ed.]

THE THYMUS GLAND.*

The thymus gland (Figs. 451 to 453), like the thyreoid, holds only a topographic relation to the respiratory tract. It is an organ which reaches its highest development during childhood and subsequently undergoes retrograde changes, so that it is almost entirely absent in adult life. At its first formation it resembles a true epithelial gland, but soon loses these characteristics and becomes a lymphoid structure, which is long and flat, and consists of two lobes, usually completely separated by connective tissue. Both lobes are in contact for a certain distance along their internal margins; they are very irregularly shaped, exhibiting deep notches which may be so extensive as to divide one of the lobes into a number of completely separated segments. The upper extremities of the lobes are usually pointed, while the thicker inferior extremities are only slightly narrower than the middle portion of the gland.

The lobes are usually unequal in size, the right being frequently the larger, although the reverse condition may obtain. They are further subdivided into small oblong areas or *lobules* which are surrounded by connective tissue, and are connected by narrow bridges of tissue with a common thread-like column, the *central tract*.

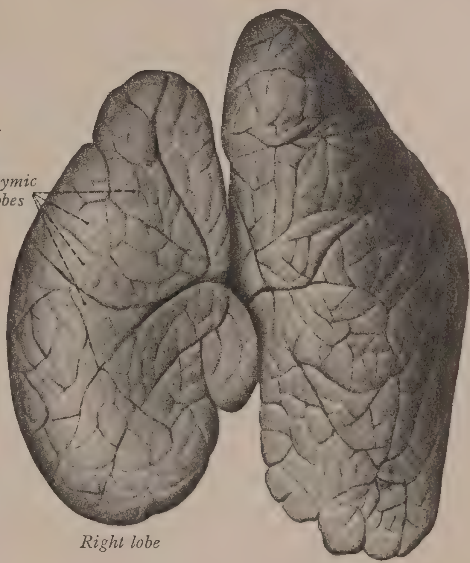


FIG. 453.—The thymus gland of a two-year-old child seen from in front.

The gland is about twice as long as it is broad, and, with the exception of the middle broadest portion, it is flat. It is situated in the upper part of the anterior mediastinum, between its two laminæ (see page 109), behind the manubium and the upper portion of the gladiolus, and in front of the anterior surface of the pericardium, the innominate veins (particularly the left), and the aortic arch and its branches. The upper extremities of the lobes of the thymus often pass upward into the neck, occasionally extending as far as the thyreoid gland, in which case they are situated behind the sternothyreoidei and sternohyoidei. The size and development of the gland are subject to great variation.

The thymus gland is rather soft; it is grayish-red in color and is usually quite pale on account of its poor blood-supply.

Until the second year the thymus enlarges and keeps pace with the general growth of the body. From the third to the fourteenth year it remains stationary, and then gradually undergoes

* In the calf this structure is known as the sweetbread.

FIG. 455.—Frontal section of the thoracic and abdominal cavities, seen from behind.

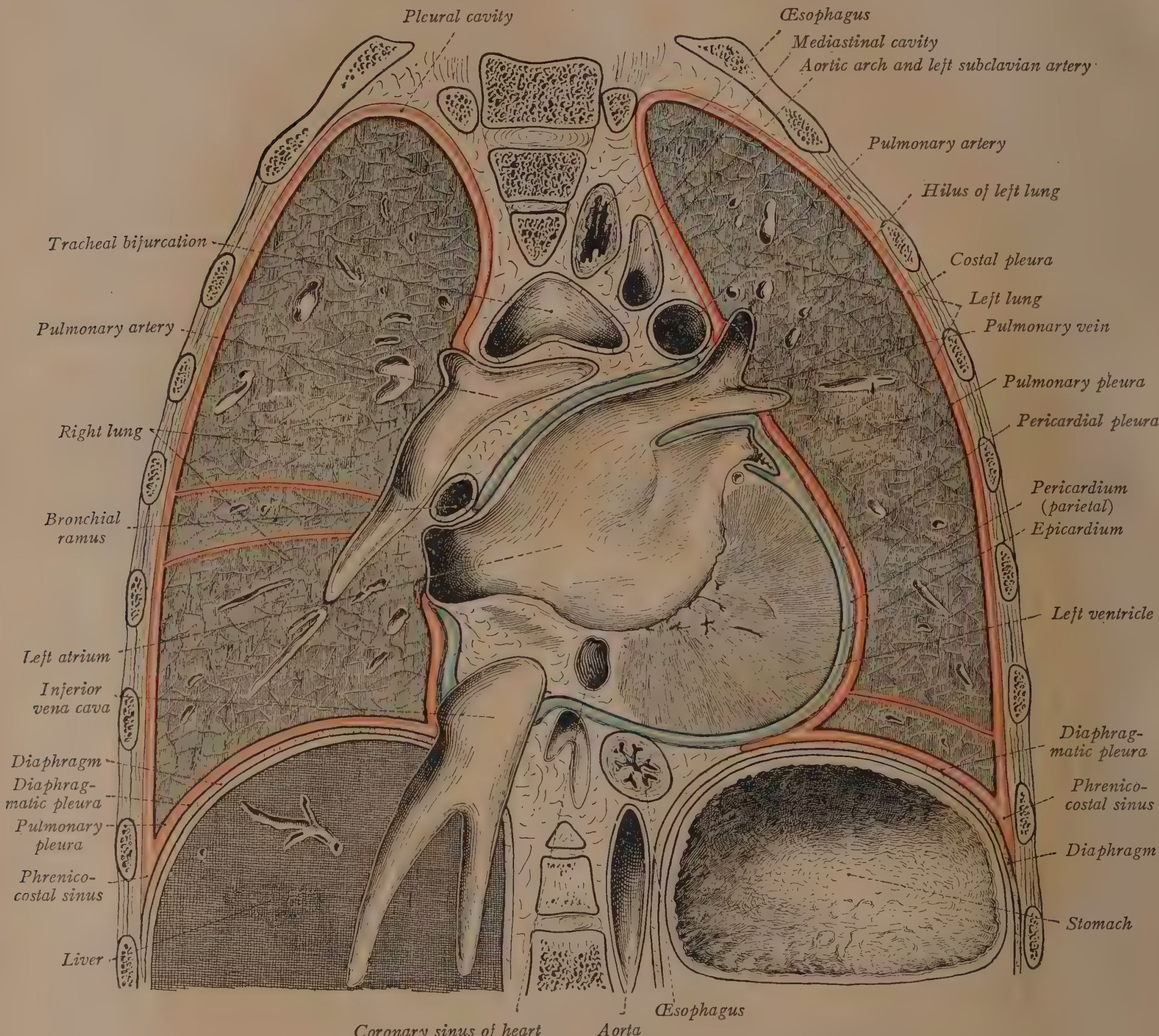


FIG. 454.—Diagram of the arrangement of the pleuræ and pericardium, as seen in frontal section. The pleura is red the pericardium blue.

a retrograde metamorphosis, gradually becoming penetrated by fatty tissue which finally preponderates, so that in the adult the thymus has usually been replaced by a fatty body containing remains of the original gland and having its general shape.

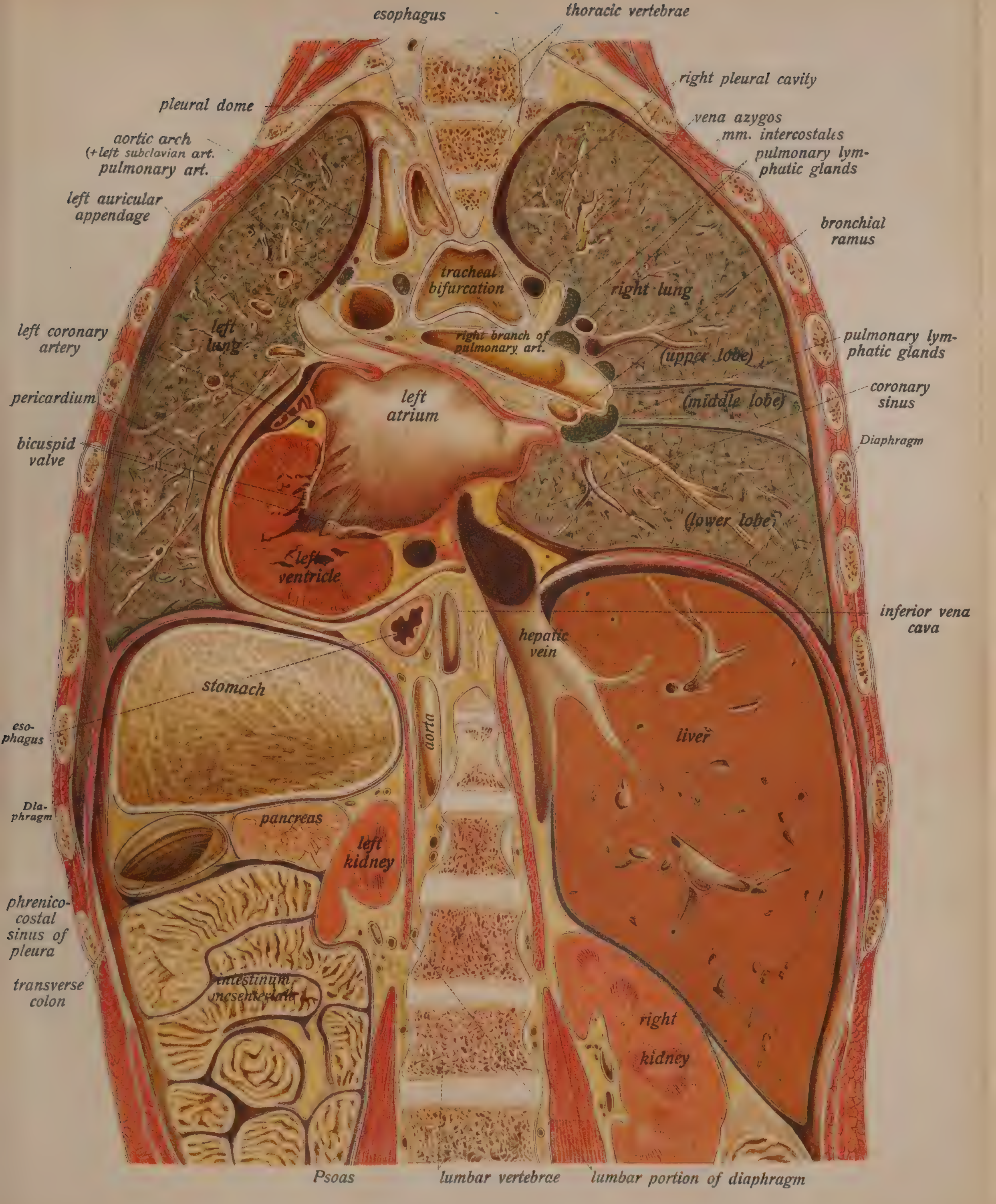

esophagus
thoracic vertebrae
right pleural cavity
pleural dome
vena azygos
mm. intercostales
aortic arch
(+left subclavian art.
pulmonary art.
pulmonary lymphatic glands
left auricular appendage
bronchial ramus
tracheal bifurcation
right lung
left lung
left coronary artery
right branch of pulmonary art.
(upper lobe)
pulmonary lymphatic glands
coronary sinus
left atrium
(middle lobe)
pericardium
bicuspid valve
Diaphragm
(lower lobe)
left ventricle
inferior vena cava
hepatic vein
stomach
liver
esophagus
aorta
Diaphragm
pancreas
left kidney
phrenico-costal sinus of pleura
transverse colon
intestinum mesenteriale
right kidney
Psoas
lumbar vertebrae
lumbar portion of diaphragm

Fig. 455.

The thymic arteries come chiefly from the internal mammary, although some are supplied by the inferior thyreoid. Most of the thymic veins empty into the left innominate; the lymphatics drain into the neighboring anterior mediastinal glands; and the nerves are derived from the sympathetic.

The first rudiments of the thymus are epithelial and arise from the third pharyngeal pouches similarly to the parathyreoid bodies. The diverticula soon become constricted from their origins, so that even when an epithelial structure the thymus assumes the characteristic of a ductless gland. This stage is followed by the metamorphosis of the epithelial rudiment into a lymphoid organ, a change for which no explanation has as yet been furnished.

THE MEDIASTINUM AND THE PLEURA.

The heart is usually considered as a viscus of the thoracic cavity, since it is situated within the pericardium and takes up a considerable portion of the thoracic space. In addition the thoracic cavity also contains the following viscera: the thoracic portion of the trachea and its ramifications, the two lungs, the thoracic portion of the œsophagus, the thymus gland, and a large number of vessels and nerves.*

The space within the thoracic cavity and its soft parts practically corresponds to that defined by the bony thorax (see Vol. I, page 35); it communicates directly with the neck by means of the superior thoracic aperture, through which certain thoracic viscera, such as the apices of the lungs, protrude. Its floor is formed by the diaphragm (see Vol. I, page 164), the contraction and relaxtion of which exerts no inconsiderable influence upon the shape of the cavity, and its inner surface is formed by the bones of the thorax, the intercostal muscles, the transversus thoracis, longi colli, and the diaphragm, and is lined throughout by the endothoracic fascia. Within it are situated three separate serous cavities, the single pericardial cavity (see page 181) and the two (paired) pleural cavities.

Each lung lies in its own serous sac, formed by the *pleura*, the visceral layer of which covers the entire pulmonary surface, with the exception of the hilus (see page 103). The visceral layer is firmly adherent to the substance of the lung, and both in inspiration and in expiration is closely applied to the parietal layer, so that the pleural cavity is nothing more than a capillary space. The two pleural cavities are separated from each other by a broad median partition known as the *mediastinal septum* or the *mediastinum* (Fig. 456), and the heart, situated within the pericardium, divides the mediastinal space into two cavities, the *anterior mediastinum*, situated anteriorly, and the *posterior mediastinum*, situated posteriorly (Figs. 457 and 458). Neither of these cavities are actual spaces, since they are filled by the thoracic viscera, vessels, and nerves; they are continuous above the heart and are limited by those portions of the parietal pleuræ which are known as the *mediastinal laminæ*.

The *anterior mediastinum* is the smaller of the two and is bounded anteriorly chiefly by the sternum; it is narrowest both in the sagittal and transverse directions behind the upper extremity of the gladiolus, since the two mediastinal laminæ are in contact in this situation immediately behind the bone, but superiorly and especially inferiorly it is broader, as the two mediastinal laminæ diverge so that the pericardium is uncovered by the pleura behind the lower portion of the gladiolus and the fifth and sixth costal cartilages. The mediastinal septum is consequently

* A detailed account of these vessels and nerves will be found in the sections upon Angiology and Neurology, as well as in the text-books and atlases of topographic anatomy.

obliquely placed and its lower portion extends for a considerable distance to the left. The anterior mediastinum attains a considerable sagittal diameter only behind the manubrium, the remaining cavity being filled by loose areolar tissue; the upper portion, however, contains the thymus gland, or rather fatty tissue surrounding the remains of the thymus, the internal mammary vessels, and the sternal and anterior mediastinal lymphatic glands.

The *posterior mediastinum* is bounded posteriorly by the vertebral column, anteriorly by the heart or pericardium, and laterally by the posterior mediastinal laminæ. It is much more

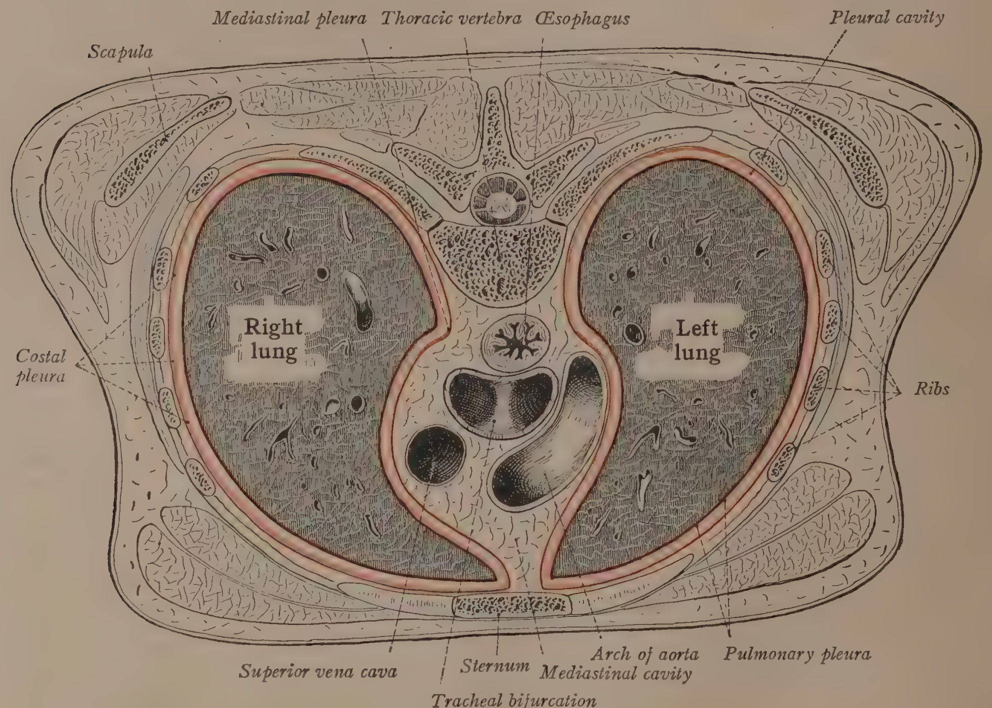


FIG. 456.—Diagram of the arrangement of the pleuræ above the heart as seen in transverse section.

capacious than the anterior mediastinum and contains the following structures (Figs. 457, 458, and 460): the œsophagus with the vagus nerves forming the œsophageal plexus; the thoracic descending aorta; to the right of these the vena azygos, which in the upper portion of the mediastinum passes about the root of the right lung to empty into the superior vena cava; to the left of and behind the aorta, the vena hemiazygos; and immediately in front of the vertebral column the thoracic duct, the posterior mediastinal lymphatic glands, and the splanchnic nerves.

The *upper portion of the mediastinum* (Figs. 456 and 459), which is not divided by the peri-

cardium into an anterior and a posterior cavity, contains the upper portion of the thoracic œsophagus, the trachea and its bifurcation, the arch of the aorta and its branches, the superior vena cava with the terminal portions of the vena azygos and the innominate veins, the pulmonary arteries and a small portion of the pulmonary veins, and the bronchial lymphatic glands.

The pleural cavities which are separated by the mediastinum are designated as the right and left pleural cavities. Corresponding to the variations in the shape of the lungs and to the oblique position of the heart, they differ in their size and shape, although they are similarly formed. The

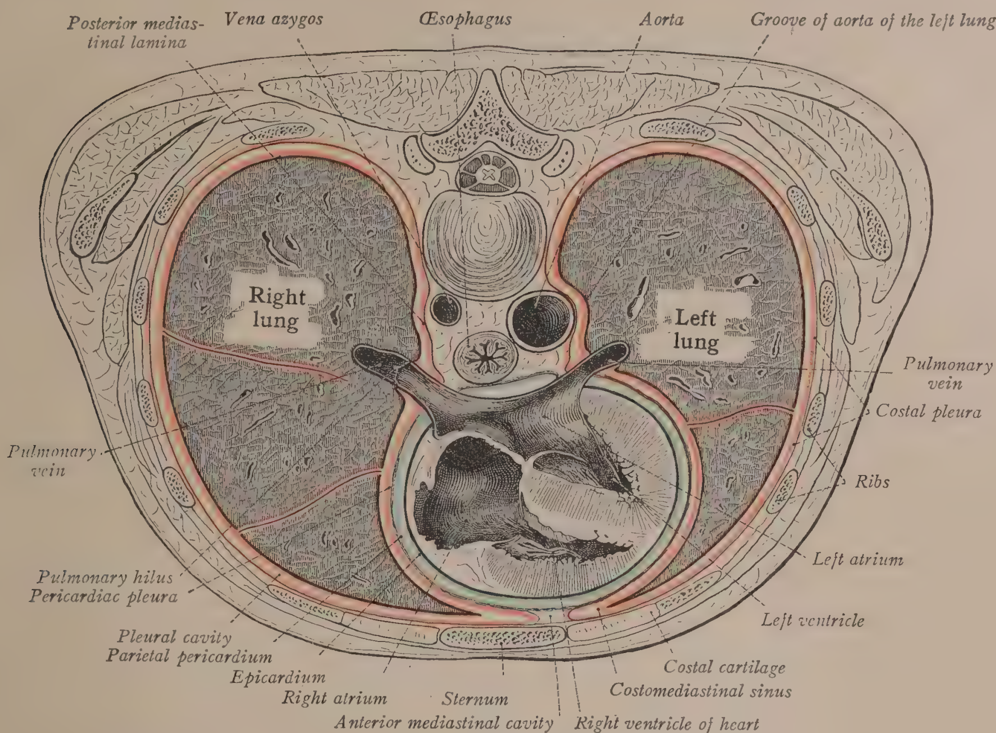


FIG. 457.—Diagram of the arrangement of the pleuræ and pericardium in the region of the hilus of the lung as seen in transverse section.

parietal pleura is differentiated into a number of portions which are named according to the part of the thoracic boundary with which they are in contact. That portion which lines the inner surface of the ribs and intercostal muscles and forms the lateral wall of the pleural cavity is designated as the *costal pleura* (Figs. 456 and 457); the floor of the cavity is formed by the *diaphragmatic pleura* (Figs. 455 and 456), which lies upon the diaphragm; the superior extremity of the cavity which projects beyond the superior thoracic aperture is called the *dome of the pleura* (Figs. 451, 452, and 455); and its inner wall is formed by the *mediastinal pleura* (Fig. 456), which is further

FIG. 459.—Transverse section of the thorax at the level of the fourth thoracic vertebra.

FIG. 460.—Transverse section of the thorax at the level of the nipples.

FIG. 461.—The left pleural cavity.

FIG. 462.—The right pleural cavity.

In the last two figures the ribs together with the clavicle have been removed, and with them the lateral wall of the pleural cavity. The lungs have been cut away close to the hilus, so that one looks into the pleural cavity on the parietal pleura.

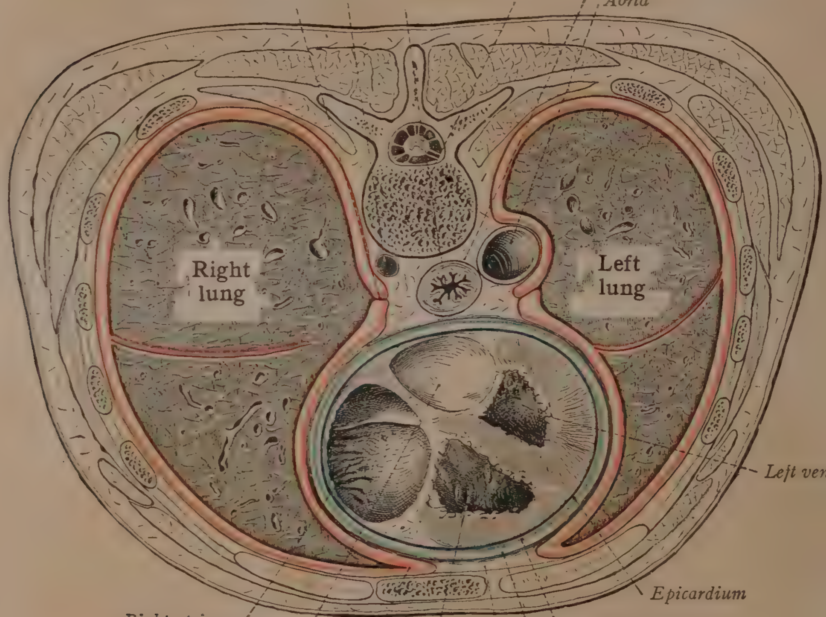


FIG. 458.—Diagram of the arrangement of the pleuræ and pericardium below the hilus of the lung as seen in transverse section.

[In these three figures (Figs. 456, 457, and 458) the pleura is red and the pericardium blue.]

subdivided into the *anterior* and *posterior mediastinal laminæ* and the *pericardiac pleura* (in contact with the pericardium) (Fig. 457). Within the limits of the mediastinal pleura the parietal and visceral layers become continuous in two situations. The first of these is at the pulmonary hilus, where the pericardiac pleura loosely envelops the vessels and bronchi of the root of the lung and passes to the surface of the viscus, and the second is in the region of the *pulmonary ligament*, a duplicature of the mediastinal pleura which commences as an immediate prolongation from the

Fig. 459.

Fig. 460.

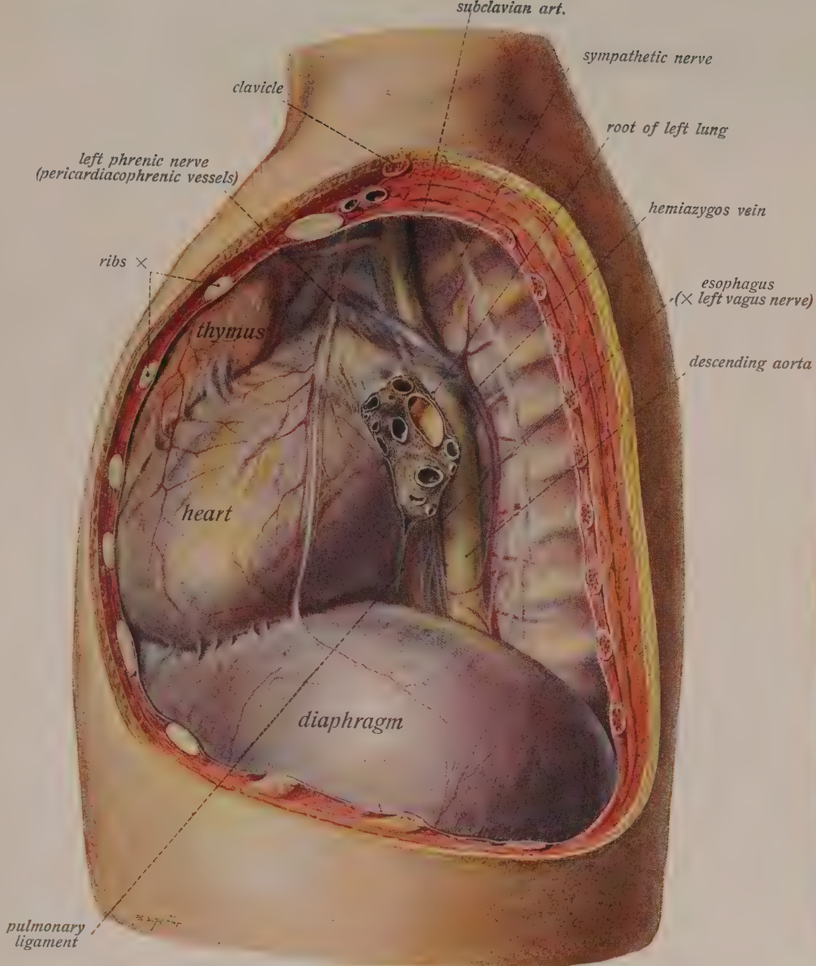


Fig. 461.

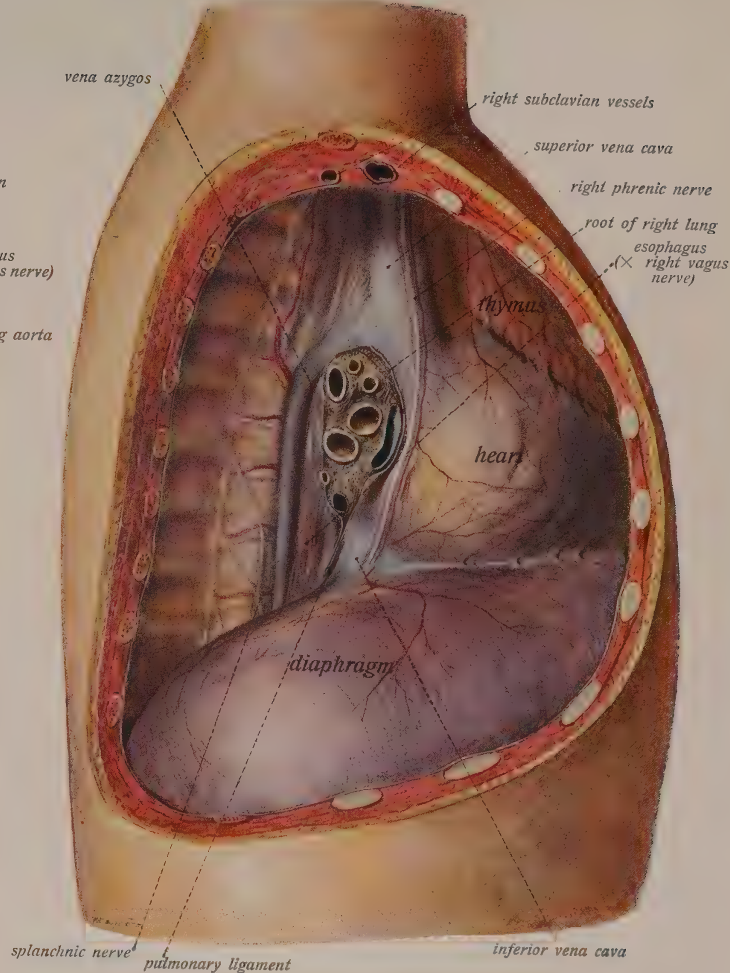


Fig. 462.

pulmonary hilus and extends downward almost to the inferior margin of the lung and to the diaphragmatic pleura. It usually terminates by a free margin just above the diaphragm. In contrast to the separation of the layers at the pulmonary hilus, the anterior and posterior layers of the pulmonary ligament are in immediate contact.

In those situations where the individual portions of the parietal pleura pass into each other at an angle, capillary spaces are formed in which the sharp pulmonary borders (anterior and lower) penetrate during inspiration, although even during the deepest inspiration the lung cannot be made to entirely fill them. They are known as the pleural sinuses. The *phrenicocostal sinus* (Figs. 413, 454, and 455) is situated between the costal and the diaphragmatic pleuræ, which are in contact for quite a distance during expiration, but as a result of the contraction of the diaphragm during inspiration they are partly separated by the descending inferior margin of the lung.

In a similar manner the anterior mediastinal and the costal pleuræ form the *costomediastinal sinus* (Figs. 457 and 460), the lower portion of which is particularly well developed. It is not so acute as the phrenicocostal sinus and is usually entirely filled during inspiration by the anterior margin of the lung. In its neighborhood not infrequently lobules of fat enveloped in pleura, the *adipose folds*, occur, and they may present villous appendages which are termed *pleural villi*.

The pleural limits in general correspond with those of the lung in the state of deepest inspiration, but the inferior pleural boundary extends somewhat lower because the phrenicocostal sinus is not entirely filled by the lung. During inspiration the lower border of the lungs is situated posteriorly at the eleventh rib, which is one rib higher than the pleura; during expiration it is 5 or 6 cm. above the inferior pleural limit. The dome of the pleura, like the apex of the lung, is considerably above the clavicle and is situated opposite to the neck of the first rib in the concavity of the arch of the subclavian artery (Fig. 455). The right mediastinal pleura almost exactly follows the right anterior pulmonary border and frequently passes beyond the middle line behind the sternum, so that the area of contact of the two mediastinal pleuræ is frequently situated at the left sternal margin, but the left mediastinal pleura usually extends only to the left sternal margin, from which it deviates laterally in the region of the fifth or sixth cartilage, so that the pericardium is uncovered by the pleura in this situation and is in immediate contact with the anterior thoracic wall. In the upper portion of the thoracic cavity the mediastinal pleura loosely invests the thymus gland or its remains, the large vessels situated above the heart, especially the aortic arch and its branches (particularly the subclavian artery), the innominate veins, the origin of the superior vena cava and the upper portion of the vena azygos, and the trachea and its bifurcation (Fig. 459). In the lower portion of the thoracic cavity it is in contact with all the lateral and part of the anterior surface of the pericardium, with the overlying phrenic nerves and superior phrenic arteries; behind the heart with the thoracic aorta, the thoracic portion of the œsophagus, and the vagus nerves; upon the right with the vena azygos, upon the left with the vena hemiazygos, and upon both sides with the splanchnic nerves (Fig. 460). While the mediastinal becomes the costal pleura at an acute angle anteriorly, the transition posteriorly is quite gradual and is situated upon the lateral surfaces of the vertebral bodies.

The diaphragmatic pleura is firmly attached to the upper surface of the diaphragm and becomes continuous with the costal pleura as it forms the phrenicocostal sinus. The junction

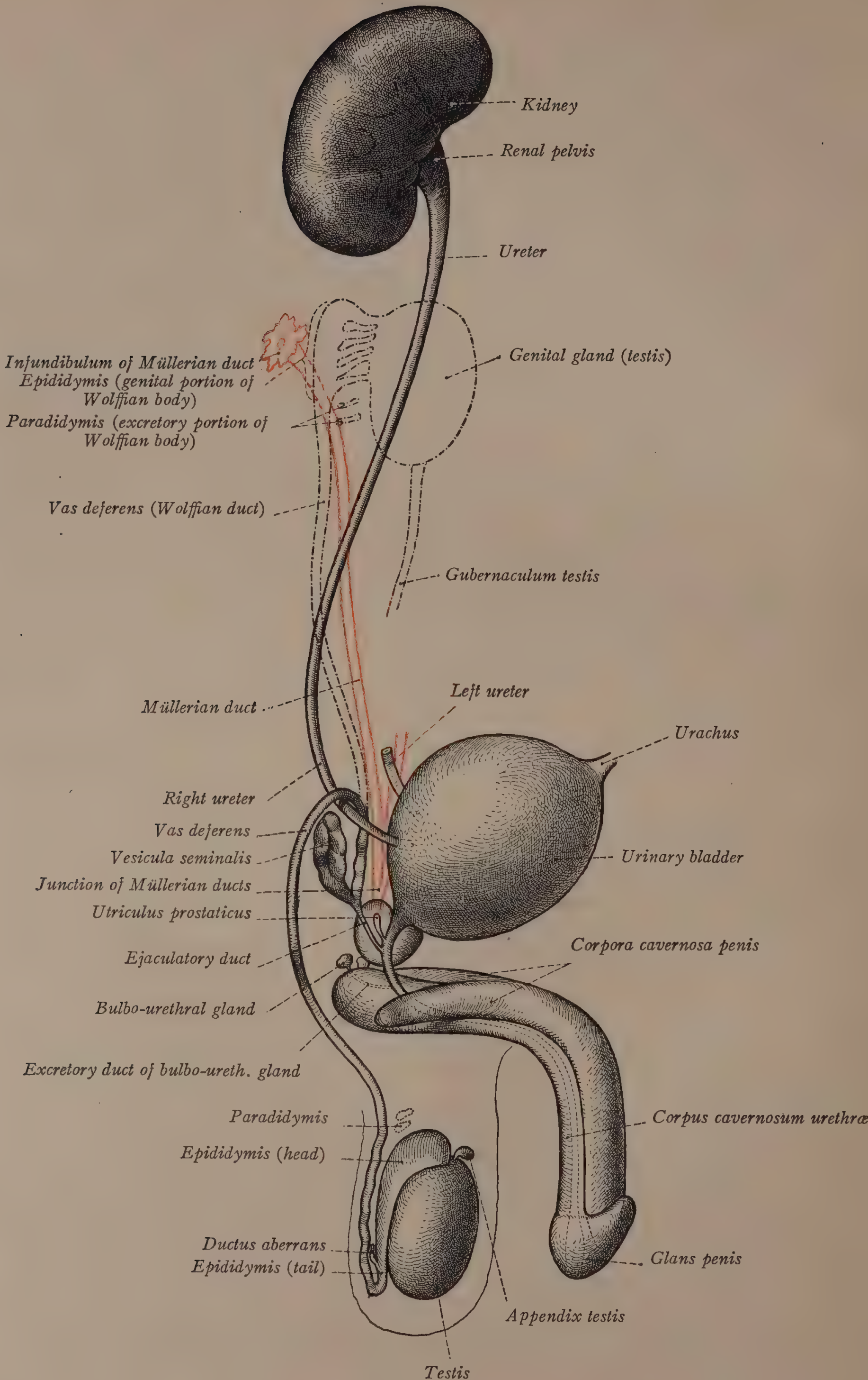


FIG. 463.—Diagram of the male urogenital apparatus with reference to its development.

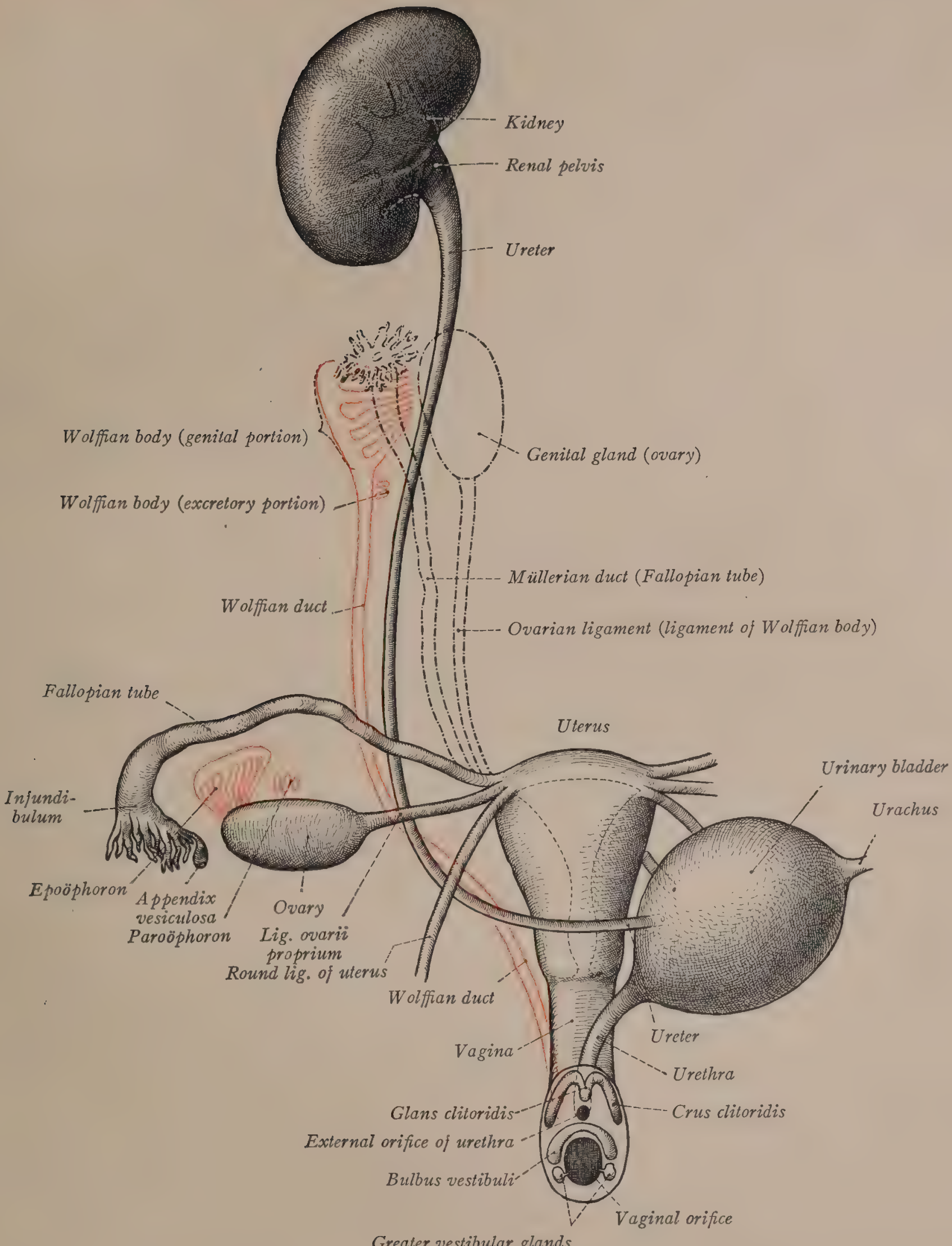


FIG. 464.—Diagram of the female urogenital apparatus with reference to its development. The embryonic structures which undergo degeneration are represented in red; the primary position of the ovaries (and in Fig. 463 the testes) and the immediately related structures is indicated by broken lines.

of the two layers is situated at the lower margin of the sixth costal cartilage in the sternal line; it then crosses the costochondral articulation of the seventh rib, the eighth, ninth, and tenth ribs, and runs to the twelfth thoracic vertebra approximately parallel to the twelfth rib.

The costal pleura lies immediately upon the ribs and the intercostales interni, posteriorly upon the subcostales and intercostales externi, and is partly in contact with the intercostal vessels and nerves (in the situation where the intercostales interni are absent) and with the main trunk of the sympathetic.

The Urogenital Apparatus.

The urogenital apparatus (Figs. 463 and 464) is composed of two separate systems of viscera, the urinary organs (*organa uropoietica*) and the sexual organs (*organa genitalia*). Both systems are intimately associated not only on account of their common method of development but also because, in the male subject at least, they utilize in part the same excretory passages. In the female, however, the completely developed urinary organs are entirely independent of the genital viscera. The Wolffian bodies, which function but a relatively short time in the human subject (see page 126), hold much more intimate relations to the sexual apparatus than to the permanent urinary viscera, while the only connection between the permanent urinary and sexual organs is found in their common exits at the urogenital sinus (see page 127).

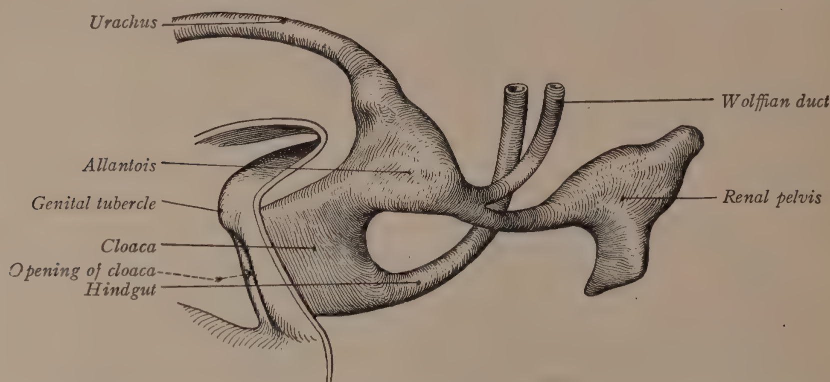


Fig. 465.—The connection of the urogenital apparatus with the intestinal tract in a two months' embryo (after a model by Keibel).

THE URINARY ORGANS (ORGANA UROPOIETICA).

The urinary organs (Figs. 463 and 464) consist of the paired glands, the *kidneys*, and of their excretory passages. The latter commence in the interior of each kidney as a dilatation known as the *renal pelvis*, which is continuous with a long narrow canal, the *ureter*, and both ureters empty into the *urinary bladder*, from which the urine is discharged externally by the *urethra*.

With the exception of the latter structure, which exhibits sexual differences, the urinary organs are practically the same in the male as in the female. The female urethra has, however, no relation with the genital tract and serves only as a urinary passage, while all of the male urethra, except the very small uppermost portion homologus to the female structure (see page 127), serves both as a urinary and a genital passage and represents the markedly elongated urogenital sinus. The slight differences which occur, for example, in the urinary bladder in the two sexes are essentially due to its relation with the differently shaped sexual viscera.

THE KIDNEYS (RENES).

The kidneys (Figs. 393, 413, 417 and 466 to 473) are two paired bean-shaped glands situated upon the anterior surface of the posterior abdominal wall. In each there may be recognized an anterior and a posterior surface, both of which are convex, although the former is more markedly so than the latter. The rounded ends of the kidneys are the superior and the inferior, the superior extremity, upon which is placed the suprarenal body, being usually somewhat broader and flatter than the inferior. The borders are medial and lateral and both are markedly rounded; the lateral border is convex and the medial concave, the concavity forming the renal hilus.

The *surface* (Figs. 466 to 469) of the kidney, which is in general smooth and evenly curved, exhibits slight and frequently indistinct impressions produced by the adjacent viscera, but owing to the firmness of the renal tissue these are not so pronounced as are those of the liver and spleen. The posterior surface of each kidney is in contact with the underlying quadratus lumborum, which produces a flattening known as the *muscular impression* (Fig. 467); the anterior surface of the right kidney presents an impression from the liver, which is usually indistinct and is designated as the *hepatic impression* (Fig. 468); and the same surface of the left kidney is in relation with the pancreas and the spleen (Fig. 393), and exhibits the *splenic impression* (Fig. 469).

The adult kidneys are usually smooth or show but faint indications of the lobulation which is markedly characteristic of the fetal structure and still quite distinct in the viscus of the newborn (Figs. 471 and 472). Both kidneys are approximately of the same size and shape, although the left one is frequently larger, although narrower and longer, than the right; these differences, however, are subject to marked individual variation, as is also the shape and position of the organ in general. In very rare instances the two kidneys are almost exactly alike. The dimensions of the organs vary considerably, but they are usually about 10 to 12 cm. long, 5 to 6 cm. wide, and 3 to 4 cm. thick.

The two kidneys are situated upon the posterior abdominal wall in such a manner that their superior extremities converge at an acute angle; the inferior extremities are about twice as far from the median line as are the superior (Fig. 413). The vertical plane which bisects the kidney is obliquely placed between the frontal and sagittal planes, but it is somewhat nearer the former. The left kidney is usually situated at a somewhat higher level than the right and it is frequently longer.

The kidneys are situated in the lumbar region. The superior extremity usually corresponds to the upper margin of the twelfth thoracic vertebra, the inferior to the upper margin of the third lumbar, and the viscus consequently extends the length of three lumbar vertebræ (and of the three intervertebral discs). Not infrequently the right kidney extends downward to the lower margin of the body of the third lumbar vertebra, while the left may extend upward to the lower margin

FIG. 466.—The left kidney seen from behind.
FIG. 467.—The right kidney seen from behind.
FIG. 468.—The right kidney seen from in front.
FIG. 469.—The left kidney seen from in front.
FIG. 470.—The kidney with its fibrous capsule divided by a frontal section.
FIG. 471.—Kidney of a child showing distinct lobulation.
FIG. 472.—The kidneys and suprarenal bodies of an advanced fetus.
FIG. 473.—The renal pelvis and sinus laid open by a frontal section.
The vessels and fat tissue of the sinus have been removed.

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of the eleventh thoracic vertebra. The twelfth rib passes obliquely somewhat above the middle of the kidney, dividing it into two "unequal halves."

The kidney, together with the suprarenal body to which it is attached by a layer of connective tissue, is surrounded by an *adipose capsule* which is quite marked in the adult and almost entirely absent in the newborn. It is more marked upon the lateral and posterior surfaces than upon the anterior, and frequently attains quite a considerable thickness. Only the anterior surface of the kidney is invested by peritoneum, which in the adult is but loosely attached, being separated from the adipose capsule by areolar tissue. The peritoneal covering of the left kidney is derived partly from the bursa omentalis.

The superior extremity and a portion of the internal margin of the kidney are in immediate contact with the suprarenal body; the remaining portions are separated from the contiguous viscera by the adipose capsule and the peritoneum. The posterior surface is in front of the quadratus lumborum and the crura of the diaphragm (Fig. 413). The anterior surface of the right kidney is in relation with the lower surface of the right lobe of the liver (impressio renalis), the descending portion of the duodenum, and the ascending colon; the corresponding surface of the left kidney borders upon the spleen (facies renalis), the tail of the pancreas (indirectly upon the stomach), and the descending colon or the splenic flexure. The internal margin of each kidney is in relation with the outer border of the psoas major.

The markedly concave depression in the middle of the internal border of the kidney, which is termed the *hilus*, appears like an irregular longitudinal fissure, and gives entrance to the arteries and exit to the veins and ureter (Figs. 466 to 470). The latter is the most posterior and inferior structure in the hilus; the vessels are situated superiorly, the artery being behind and the vein in front. The hilus leads into the *renal sinus* (Figs. 470 and 473), a space which is almost entirely surrounded by renal tissue. It opens externally through the hilus and contains an abundance of fatty tissue (Fig. 470), the ramifications of the vessels and the commencement of the ureter, the calyces and renal pelvis. It corresponds to the kidney in shape, is placed like this viscus almost in the frontal plane, and is markedly flattened from before backward.

The surface of the actual renal tissue is enveloped by a rather thin *fibrous capsule* (Fig. 470), which may be readily pulled away from the renal parenchyma, being separated from it by loose connective tissue containing a small quantity of involuntary muscle, the *muscular capsule* of the kidney.*

* This muscular capsule is very thin except at the bases of the renal papillæ, where it is thickened and is known as the *sphincter papillæ*.

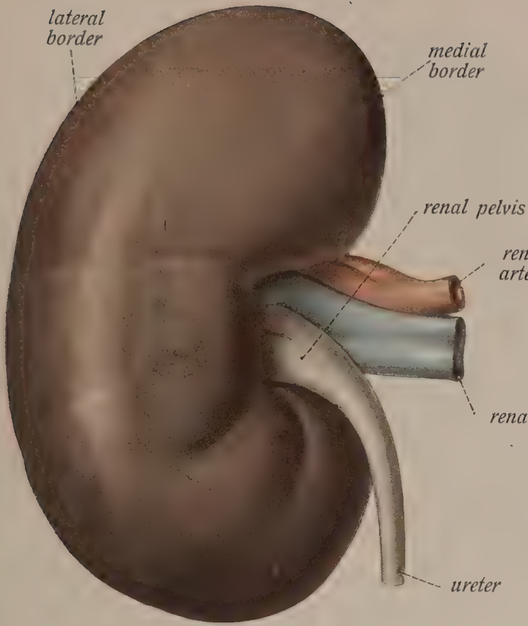

Fig. 466.

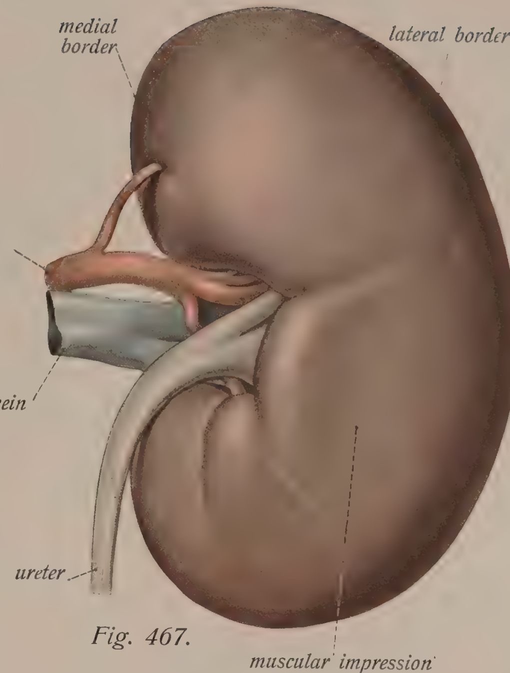

Fig. 467.

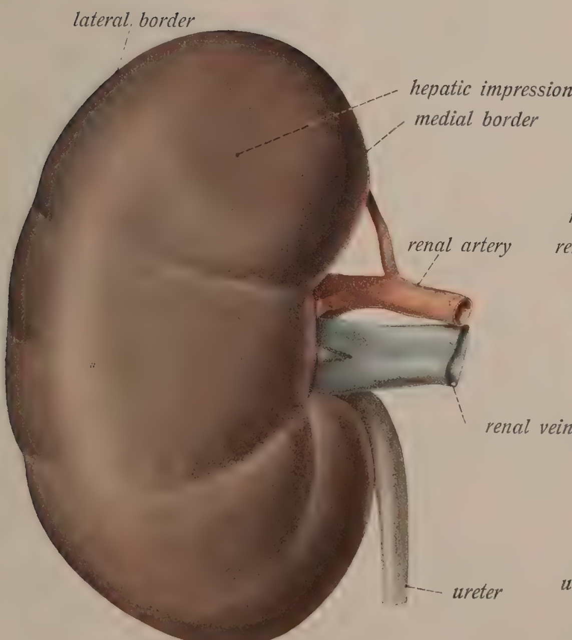

Fig. 468.

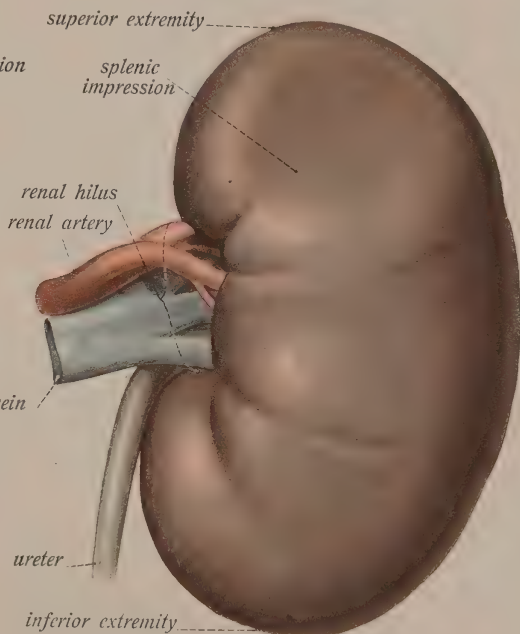

Fig. 469.

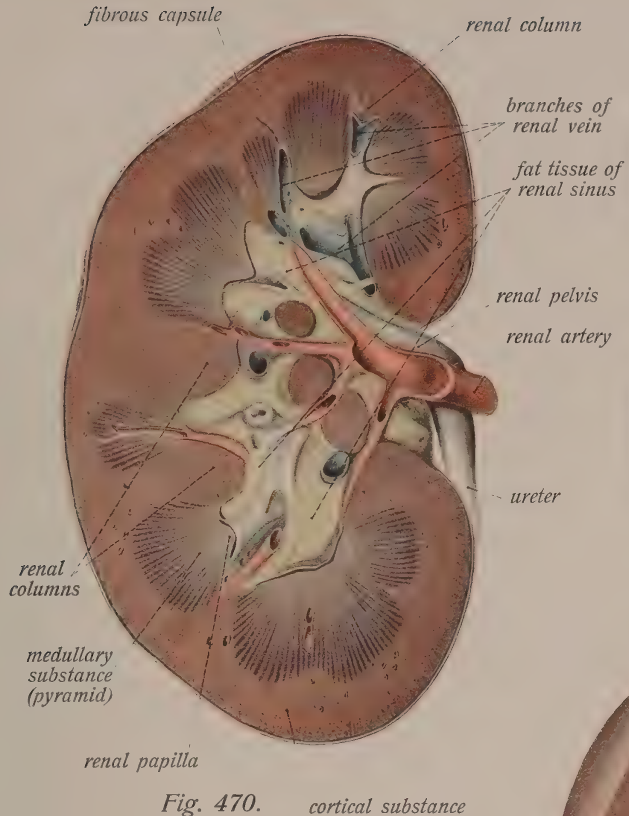

Fig. 470.

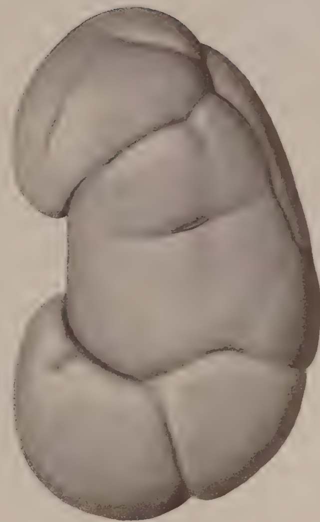

Fig. 471.

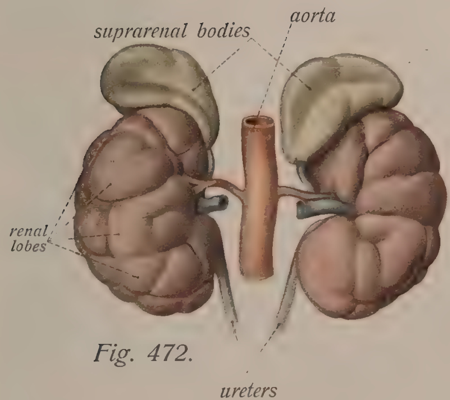

Fig. 472.

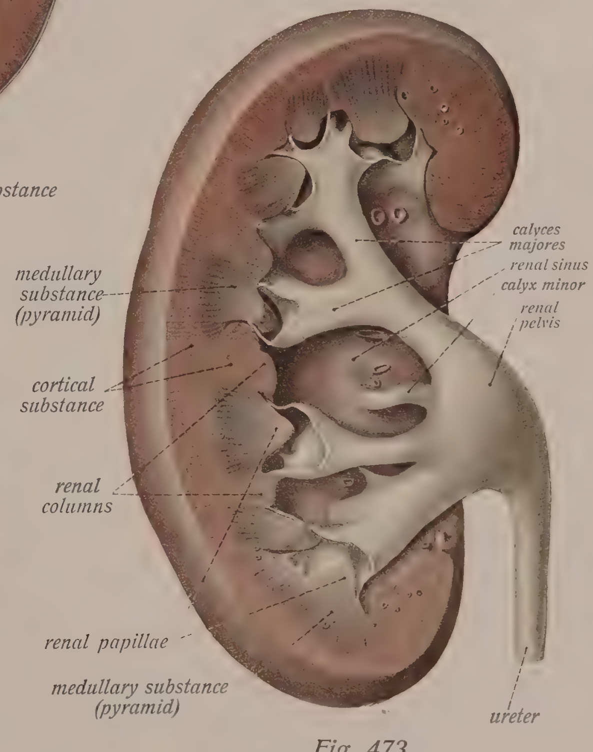

Fig. 473.

The renal parenchyma is differentiated into the cortex and the medulla (Figs. 470 and 473). The *cortex* contains the majority of the convoluted tubules, is more vascular and consequently usually redder than the medulla, and forms the entire surface and by far the greater portion of the bulk of the kidney.

The *medulla* is less vascular, paler, grayish-red or grayish-yellow, and distinctly striated; it contains the majority of the straight urinary tubules and forms the so-called renal *pyramids* (Figs. 470 and 473), large conical structures, the bases of which are directly continuous with the cortex. The line of junction of the cortex and medulla is usually bright red in a fresh section of kidney, because numerous small vessels pursue a parallel course in this situation.

The apices of the renal pyramids are called *renal papillæ* (Figs. 470 and 473) and are directed toward the renal sinus, into which they project as broad, pointed, and frequently flattened cones. One renal papilla usually corresponds to several renal pyramids, the apices of which have become fused together. In the human kidney the papillæ vary between seven and twelve in number, while the pyramids vary between fifteen and twenty. Upon the apex of each papilla are found the excretory orifices of the terminal portions of the straight urinary tubules, which are known as the *papillary ducts*. These orifices are termed *papillary foramina* and are barely visible to the naked eye; they vary in number from fifteen to twenty on each papilla and the area which they occupy is known as the *area cribrosa* (*cribrum benedictum*).

Certain portions of the cortex also extend to the renal sinus between the bases of the renal pyramids, appearing in cross-section as columns of cortical tissue pushed in between the renal pyramids; they are known as the *renal columns* (*columns of Bertini*) (Figs. 470 and 473). Between them and the pyramids may be seen the larger branches of the renal vessels as they make their entrance from or exit into the renal hilus.

Each pyramid corresponds to a portion of the cortex which is designated as a *cortical lobule* (*renculus*), and while in the adult kidney the neighboring cortical lobules are directly continuous, in the fetal organ they are distinctly separated and produce the characteristic lobulation (Fig. 472). In each cortical lobule there may be recognized a *radiated* and a *convoluted* portion, the latter containing the glomeruli, which are frequently visible to the naked eye as fine red points when the kidney is congested.

The system of excretory renal ducts, which terminates in the bladder by means of the ureter, commences in the renal sinus as the *renal calyces* (Figs. 470 and 473). These are rather thin-walled, flattened, cylindrical tubes which are attached at one end to the lateral margins of the renal papillæ and at the other communicate with the *renal pelvis*, a dilatation of the ureter situated within the renal sinus. Several calyces usually unite before reaching the renal pelvis (Fig. 477), so that *greater* and *lesser calyces* may be distinguished, the latter surrounding the renal papillæ in such a manner that the tip of the papilla projects into a somewhat dilated portion of the calyx, and the urine discharged from the papillary foramina is consequently poured directly into the renal calyx. The epithelium of the calyx is continuous with that covering the apex of the papilla.

The number of lesser calyces usually corresponds to that of the papillæ (seven to twelve), but the greater calyces vary greatly in number, two or three sometimes forming the entire renal pelvis, while frequently four or five of different sizes unite to form the common cavity.

The *renal pelvis* (Figs. 473 and 477) is a short, flattened, funnel-shaped, thin-walled tube,

the greater portion of which is situated within the renal sinus. Its apex is at the hilus and passes into the ureter without demarcation, while the broad end of the funnel is continuous with the calyces. The walls of the calyces, of the pelvis, and of the ureter are of similar structure.

The renal arteries are branches of the abdominal aorta. This diminishes considerably in caliber after giving off these vessels, which are usually large in comparison with the size of the kidney. Not infrequently the renal artery is double, or accessory vessels enter the viscus usually outside of the hilus.

The renal veins are correspondingly large, and empty into the inferior vena cava. The lymphatic vessels pass to the lumbar trunks, and the nerves are derived from the sympathetic and enter the organ with the arteries.

THE URETER.

The *ureter* (Figs. 413, 477 to 481, and 498 to 500) is a paired, approximately cylindrical canal, which when empty is markedly flattened from before backward. It is the continuation of the renal pelvis, commencing at the hilus and terminating by emptying into the postero-inferior portion of the bladder. Two portions may be recognized in it: (1) an *abdominal portion*, situated in the abdominal cavity, and (2) a *pelvic portion*, situated in the true pelvis. The length of the entire ureter is about 30 cm.

In their course from the hilus to the bladder the *abdominal portions* of both ureters converge (Fig. 413). They are situated behind the parietal peritoneum upon the anterior surface of the psoas major, and are crossed at an acute angle by the overlying internal spermatic vessels. At the junction of the true and the false pelvis each ureter crosses the common iliac or more rarely the external iliac vessels, being situated in front of these structures, and just before this crossing it presents a rather marked fusiform dilatation, while at its exit from the renal pelvis it is usually distinctly constricted.

The *pelvic portion* of the ureter follows the general curvature of the wall of the true pelvis, and there is a distinct angulation at its junction with the abdominal portion. It usually commences with a slight constriction, which follows immediately upon the marked dilatation of the lower part of the abdominal portion.

Corresponding to the difference in the contents of the true pelvis in the male and female, the ureter has different relations in the two sexes. In the male the course of the pelvic portion is relatively simple. It is covered by the parietal peritoneum and runs in front of the internal iliac artery to the lateral portion of the posterior wall of the bladder, where it crosses the vas deferens in such a manner that it is situated posterior and external to this structure (Figs. 478, 480, and 481).

In the female it is intimately related to the genital apparatus (Figs. 498 to 503). It is situated in the base of the broad ligament (see page 77), first alongside the cervix of the uterus and then for a distance of 1 to 1.5 cm. along the anterior vaginal wall before it enters the bladder. It is also only a few centimeters from the free margin of the ovary.

When empty the ureter is collapsed, since its walls are thin and yielding, but it is capable of great dilatation. Its wall consists of a mucous coat, of a muscular coat of three layers (internal, middle, external), and of a fibrous coat.*

The arteries for the renal pelvis are furnished by the renal, those for the abdominal portion

* Before the ureter enters the wall of the bladder it receives a short muscular sheath from the vesical wall, the so-called *ureteral sheath*, the portion invested by the sheath being termed the *extramural portion.*

of the ureter by the internal spermatic, and those for the pelvic portion by the middle hemorrhoidal or the inferior vesical. The lymphatic vessels are not well known and probably pass to the lumbar trunks. The nerves are supplied by the sympathetic.

THE URINARY BLADDER (VESICA URINARIA).

The *urinary bladder* (Figs. 413, 476, 478 to 483, and 498 to 503) is a sack-like dilatation of the urinary passages which serves as a collecting reservoir, the size and shape of which is dependent upon the degree of distention. Three chief portions may be recognized in it: the middle and larger portion of the bladder is the *body* (Fig. 478); the upper portion, which is distinctly pointed, especially in the newborn, is the *vertex;* and the lowermost portion, directed toward the perineum, is called the *fundus* (Fig. 479).

The shape of the bladder and the thickness of its wall vary with the amount of contained fluid, and its shape is also subject to certain sexual and individual variations. The full bladder is ellipsoidal or ovoid, and in the female particularly is frequently markedly flattened from before backward. The empty bladder is irregularly spherical and flattened from above downward, and in the female is frequently indented by the overlying and anteverted body of the uterus (see page 149). In the child the full bladder is often pear-shaped rather than ovoid.

The *middle umbilical ligament* (Figs. 413, 476, and 479) is attached to the vertex of the bladder and in the adult is a fibrous cord which gradually disappears upon the slightly pointed vertex. It represents an obliterated embryonic canal, known as the *urachus* (see page 126), the vesical extremity of which is usually still patulous in the newborn. It passes upward to the umbilicus upon the anterior abdominal wall and is situated in front of the peritoneum (see page 81) (Fig. 412). Two lateral fibrous cords also run to the umbilicus from the lateral walls of the bladder (Fig. 412); they are known as the *lateral umbilical ligaments* and are the remains of the obliterated hypogastric arteries. In the adult they gradually disappear at the umbilicus, where they join the middle umbilical ligament at an acute angle, forming with it the foveæ supravesicales (see page 81).

The bladder is situated in the anterior portion of the pelvic cavity behind the pubic symphysis (Figs. 480 and 481). Its axis is not vertical but approximately parallel to that of the pubic symphysis, passing obliquely from before backward and from above downward. When empty the vertex does not project above the symphysis, although when strongly distended it may extend far above this point. The anterior vesical wall consequently borders upon the anterior pelvic wall, and upon the posterior surface of the anterior abdominal wall when the bladder is full, and the lateral surfaces of the empty or slightly filled bladder are in relation with the lateral walls of the pelvis. In the female (Figs. 500 to 503) the posterior surface is in contact with the uterus and the upper portion of the vagina, while in the male (Figs. 478, 480, and 481) it is in relation with the seminal vesicles and the vasa deferentia (particularly the ampullæ) and with the rectum (when the bladder is distended) or the intestinal coils lying in the rectovesical pouch (see page 55).* When the bladder is full the fundus is almost horizontal, but when the bladder is empty it slants obliquely forward and from above downward. Together with the lower portion of the posterior

* In the female, however, the posterior wall of the bladder even when empty is always in relation with the uterus since the vesico-uterine pouch is always empty when the position of the uterus is normal.

FIG. 474.—Right suprarenal gland seen from in front.

FIG. 475.—Left suprarenal gland seen from in front.

FIG. 476.—The urinary bladder and prostate seen from in front.

The structures have been laid open by a longitudinal section, and the interior of the bladder further exposed by a horizontal slit.

FIG. 477.—Cast of the pelvis of the kidney.

FIG. 478.—The urinary bladder with the seminal vesicles, the ampullæ of the vasa deferentia and the prostate seen from behind and below. The prostate is partly divided longitudinally.

FIG. 479.—The urinary bladder and prostate seen from behind. The superficial musculature of the bladder has been removed.

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surface it is also partly in relation with the anterior wall of the rectum, being in immediate contact with it below, but separated from it above by the lowermost portion of the rectovesical fold. In the male the fundus is intimately adherent to the prostate (Fig. 479) (see page 135), by means of which it is attached to the pelvic floor; in the female (Figs. 500 to 503) it lies upon the middle portion of the anterior vaginal wall. The deepest point of the fundus is the site of the internal orifice of the urethra, which, corresponding to the oblique position of the vesical axis, is situated several centimeters behind the symphysis and is attached to the pelvic floor by the urogenital trigone and in the male also by the prostate.

The urinary bladder possesses three openings (Fig. 476), the two *orifices of the ureters* and the *internal orifice of the urethra*. All three openings are within 1 or 2 cm. of each other in the region of the fundus, the urethral orifice being at the lowest point of the bladder and the orifices of the ureters in the lower portion of the posterior vesical wall. The ureters pass through the wall quite obliquely, and in so doing form a fold of mucous membrane, known as the *ureteric fold*, which, since the ureters are directed toward each other during their course through the vesical wall, are correspondingly convergent. Continuations of these folds pass from the orifices of the ureters toward the internal orifice of the urethra, where they gradually disappear, and the orifices of the ureters are connected by a low, transverse, slightly curved fold, which is also a continuation of the ureteric fold, so that an approximately equilateral triangle is formed, the three vesical openings being situated at its angles, its base being directed posteriorly (and above), and the apex anteriorly and below (the internal urethral orifice). This triangle is characterized by the smoothness of its mucous membrane even when the bladder is empty, and is termed the *vesical trigone* (triangle of Lieutaud).* The orifices of the ureters are obliquely placed, slit-like openings upon the ureteric folds of the vesical mucous membrane.

Near the apex of the vesical trigone there is usually an independent longitudinal elevation which extends to the internal urethral orifice and is known as the *uvula* of the bladder; it projects into the urethral orifice from behind, so that this opening is semilunar in shape.

The vesical wall consists of a mucous coat, of a muscular coat, and of a serous coat. The last named coat is not present in all parts of the viscus, but invests only the upper surface of the bladder as far as the vertex and the upper part of the lateral surfaces; at the posterior surface the peritoneum is reflected to the rectum in the male (Fig. 481) and to the vesical surface of the uterus

* The portion of the bladder corresponding to the vesical trigone together with the urethral orifice and the vesical wall attached to the prostate is also termed the *neck*.

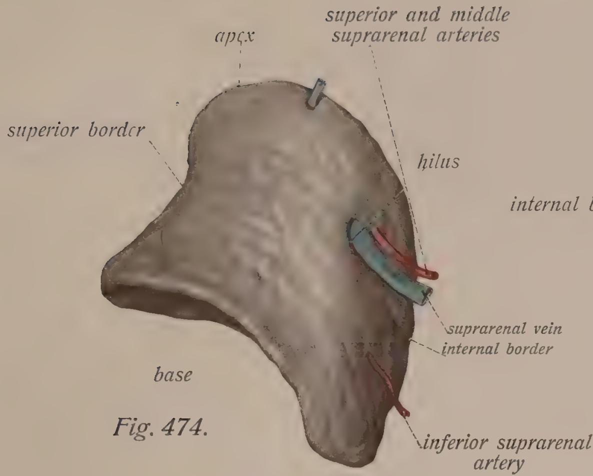


Fig. 474.

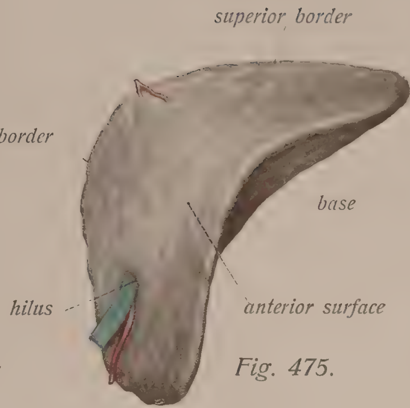


Fig. 475.

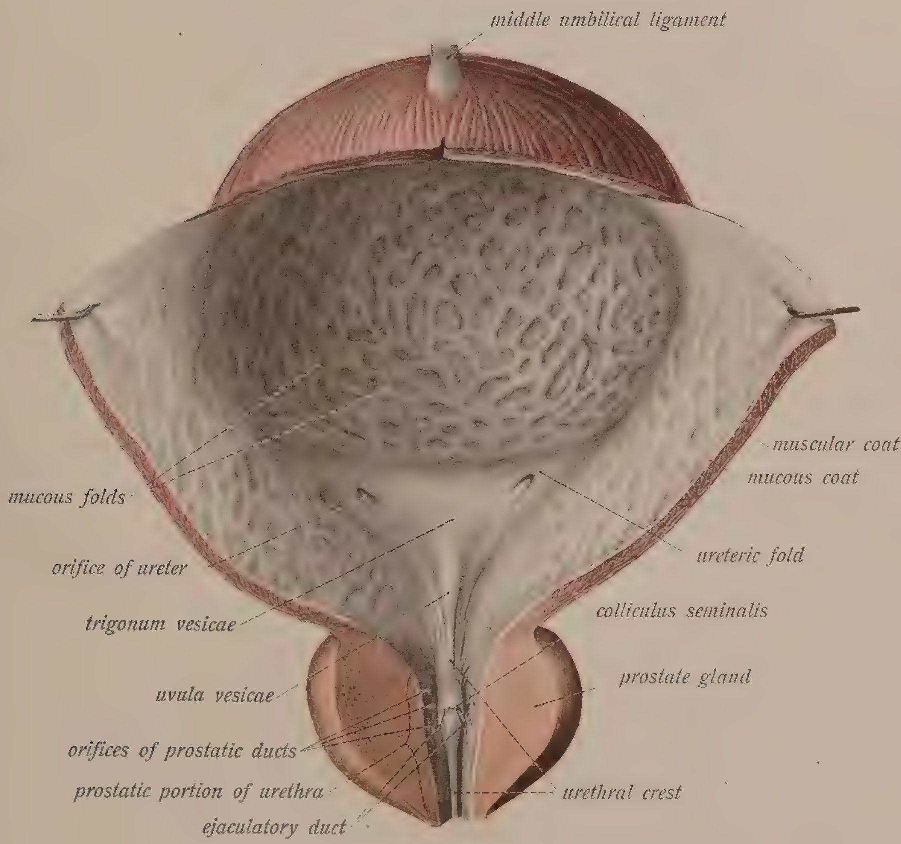


Fig. 476.

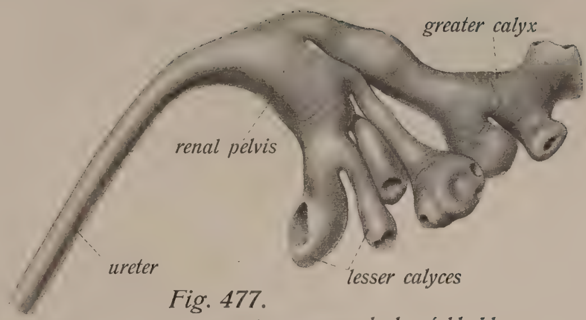


Fig. 477.

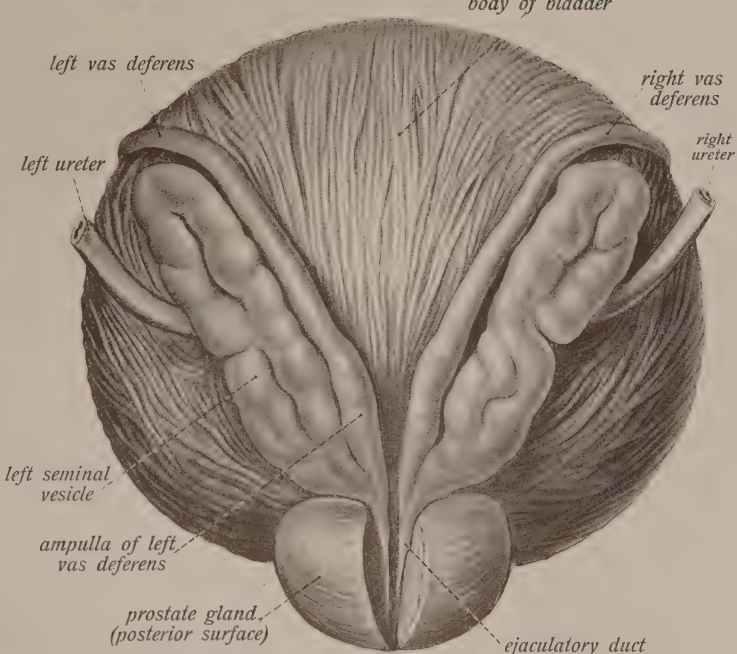


Fig. 478.

Fig. 479.

in the female (Fig. 502). It attains the lowest level in the male between the ampullæ of the vasa deferentia (see page 134). The peritoneum is but loosely attached to the lateral portions of the bladder, but at the middle segment of the viscus it is rather firmly adherent. The anterior wall, the lower portions of the lateral walls, and the fundus of the bladder have no serous covering whatever, and between the posterior surface of the symphysis and the anterior surface of the bladder the *prevesical space*, which is filled chiefly by loose fatty tissue, is situated.

The entire surface of the bladder is covered by a layer of fascia, which rests upon the external muscular layer and forms the outer coat of the bladder in those situations which are uncovered by peritoneum. It is a portion of the visceral layer of the pelvic fascia (see page 162).

The muscular coat (Figs. 478 and 479) is quite thick (about 1 cm.) when the viscus is empty, but when it is distended the muscular fasciculi become markedly separated. It consists of three layers. The outer layer (Fig. 478) consists essentially of longitudinal fibers and is reinforced by two muscular fasciculi which connect the bladder with surrounding structures. Of these the *m. pubovesicalis* passes from the posterior surface of the pubis near the symphysis and from the anterior extremity of the tendinous arch of the pelvic fascia (the "white line") to the fundus of the bladder; it is a constituent of the puboprostatic ligament in the male and of the pubovesical ligament in the female (see page 136). The *m. rectovesicalis* is present only in the male; it connects the longitudinal musculature of the rectum with the outer layer of the muscular coat of the bladder, and runs in the peritoneal fold of the same name (see page 84).

The middle layer (Fig. 479) is the strongest of the three muscular coats, and consists of a fairly continuous stratum of circular fibers which are oblique in the upper and exactly transverse in the lower portion of the bladder. A thickening of this layer at the internal orifice of the urethra forms what is termed the *urethral annulus* and serves as a *m. sphincter vesicæ*.

The internal layer forms a wide-meshed muscular reticulum, the majority of the fibers pursuing a longitudinal direction. It is situated immediately beneath the mucous membrane.

The musculature of the ureter remains independent even within the wall of the bladder (the intramural portion of the ureter), and is characterized by strong longitudinal fasciculi which penetrate the muscular layers of the bladder obliquely and become lost in the thick muscular wall of the vesical trigone. The ureter penetrates the vesical wall at such an acute angle that it is surrounded by it for 1 to 2 cm. according to the degree of vesical distention, and it retains its fibrous coat almost until it reaches the orifice. As a consequence of this oblique penetration the resulting lip of mucous membrane above the orifice acts as a valve, which is closed by the pressure of the urine contained within the bladder and can be opened only by the contraction of the musculature of the ureter.

The mucous membrane of the bladder is of a bright red color in the living subject (cystoscopic picture), and when the viscus is empty the mucous membrane is thrown into marked folds, except in the area included within the vesical trigone, which is nearly always smooth. The folds are completely obliterated when the bladder is distended. The vesical mucous membrane contains lymphatic nodules, but no true glands.

When markedly distended the bladder contains over a liter, but under normal conditions it rarely contains more than 500 c.c., and usually less than this quantity. Even when markedly contracted the viscus is not entirely empty, but still contains about 50 c.c. of urine.

The urinary bladder is supplied with blood by the superior and inferior vesical arteries, both of which are branches of the internal iliac. The larger inferior vessels are direct branches of the internal iliac, while the superior vesicals are really given off by the hypogastric artery.

The veins form several plexuses within the vesical wall and empty into the pudendal and vesicoprostatic plexuses.

The lymphatic vessels pass to the small vesical lymphatic glands and thence partly into the iliac glands.

The nerves are largely furnished by the sympathetic, but are also derived from the third and fourth sacral nerves; they form the vesical plexus.

The bladder is developed from the so-called allantois (see page 126).

THE SUPRARENAL GLANDS.

The *suprarenal glands* (Figs. 393, 394, 413, 472, 474, and 475) are paired structures which rest upon the upper extremities of the kidneys. They hold intimate topographic relations with these structures, but in other respects they are related to the kidneys in much the same way that the thymus gland is related to the respiratory organs. They belong to the ductless glands.

They are flat, irregular structures, the shape of which is subject to considerable variation. The two glands differ in the same individual, the left one (Fig. 474) usually having the form of a slightly curved, semilunar disc, while the right (Fig. 475) is triangular, the apex being directed upward. In each there may be recognized an *anterior* and a *posterior surface*, both of which are curved and separated by the superior border. The *inferior surface*, which is also directed slightly outward and backward, is in contact with the kidney; it is slightly concave and is also known as the base. There may also be distinguished an internal border and, at least in the right suprarenal body, an *apex*. Upon the anterior surface near the base there is a shallow groove which is not always distinct; it gives entrance to vessels and nerves (particularly to large venous branches) and is known as the hilus, but vessels and nerves also enter the viscus by means of smaller grooves upon its anterior surface.

The surface of the suprarenal body is usually slightly nodular and is of a yellowish-white color. Upon cross-section it is seen to consist of two distinctly demarcated portions: the *cortex*, which is yellow at the periphery and usually yellowish-brown in its deeper layers, and the *medulla*, which is dirty gray or grayish-red. Toward the margins of the organ the medulla is usually thinner than the cortex, while in the middle of the viscus it is thicker.

The suprarenal substance is unusually friable and soon undergoes decomposition in the cadaver.

The relations of the suprarenal bodies are as follows: They rest upon the kidneys, to which they are firmly attached by a layer of fascia, that upon the right side being in relation with the superior extremity of the kidney, while that upon the left rests rather upon the internal margin of this viscus. The posterior surfaces are in contact with the crura of the diaphragm. The left suprarenal gland also borders upon the renal surface of the spleen, the tail of the pancreas, and the splenic vessels, and the apex of the right one is in contact with the non-peritoneal surface of the liver, with which it is frequently rather firmly united by fasciculi of connective tissue; it produces upon the liver the inconstant suprarenal impression and is also in relation with the inferior vena cava.

The suprarenal glands are relatively very large in the fetus (Fig. 472) and in the newborn, but they do not subsequently increase in size in proportion to the general growth of the body.

Accessory suprarenal bodies are very common, and are situated either in the immediate

vicinity of the organ or at points far distant in the abdominal and pelvic cavities, especially near the genitalia; they are particularly common, for example, in the broad ligament of the uterus and in the epididymis. These small structures, which are frequently only microscopic in size, consist either of cortex and medulla, like the main viscus, or simply of cortex alone.

The arteries of the suprarenal bodies are furnished by the abdominal aorta; the middle suprarenal is a direct branch, while the superior is derived from the inferior phrenic and the inferior from the renal. The suprarenal veins empty partly into the inferior vena cava and partly into the renal. The nerves are very numerous and are all branches of the sympathetic.

The development of the suprarenal body is not yet very well understood. It would seem, however, that the medulla develops in connection with the sympathetic nervous system, while the cortex arises from the middle layer of the blastoderm (from the cœlomic endothelium).

THE GENITAL ORGANS.

Although the mature sexual organs (Figs. 463 and 464) exhibit great differences in the two sexes, they are formed in both from common indifferent rudiments. This is brought about principally by the fact that some of the parts serving as excretory urinary passages in the male gradually disappear in the female, while some of the sexual female rudiments do not develop in the male.

The sexual organs of both sexes are differentiated, though not sharply, into the *internal* and the *external genitalia*, and consist essentially of the genital gland, *i. e.*, the gland which produces the sexual products, and of a system of excretory ducts. In the male the genital gland is the testis and the excretory duct system consists of the epididymis, the vas deferens, and the seminal vesicle; in the female the genital gland is the ovary, and the excretory ducts consist of the Fallopian tubes, the uterus, and the vagina.

In addition to the genital gland and the system of excretory ducts there is a structure in both sexes which contains the outlets of both the urinary and of the sexual organs and is consequently known as the urogenital sinus, and, finally, there are also associated with them other appendages of a glandular character.

THE DEVELOPMENT OF THE URINARY AND SEXUAL ORGANS.*

The first rudiments of the urogenital system are intimately connected with a structure which is known as the *Wolffian body* or primordial kidney (Figs. 463 and 464). This arises quite early (from the fourth to the fifth week) from the cœlomic epithelium, *i. e.*, from the epithelial lining of the embryonic body cavity, which is derived from the mesoderm. In the human embryo the Wolffian body excretes urine only for a short time, but in the embryos of the other mammals it functions for a longer period. It consists of a number of tubules with glomeruli and of an excretory duct, the *Wolffian duct*, which empties into a ventral protrusion of the hindgut, the *allantois* (Fig. 465). The Wolffian body consists of a small proximal or reproductive portion and a larger distal or excretory portion. The former becomes a part of the sexual organs in the third month, forming, in the male, the epididymis, while in the female it retrogrades, its remains persisting for a long time in the broad ligament as the *epoöphoron* (see page 147). After the development of the

* Only the main facts necessary for the proper understanding of the development of the urogenital system will be considered. For further details the reader is referred to the text-books of embryology.

permanent kidney the distal portion of the Wolffian body soon atrophies, and becomes the *paro-ophoron* in the female and the *paradidymis* in the male (see pages 147 and 131). The Wolffian duct forms the vas deferens in the male but disappears entirely in the female, the caudal extremity being the last to atrophy and being still demonstrable in old fetuses at the lateral surface of the uterus and vagina (Gärtner's duct of the mammalia).

Immediately alongside the Wolffian duct and at a slightly later period, the *Müllerian duct* develops on either side of the body. It also is derived from the cœlomic epithelium, and its free cranial extremity, which is termed the *infundibulum*, remains in connection with the cœlom and consequently with the peritoneal cavity. The caudal extremities of the Müllerian ducts unite with each other before they open into the allantois. In the male this duct almost completely disappears, only the junction of the caudal extremities remaining for a short distance above its termination as the *prostatic utriculus* (see page 137), while the *appendix testis* is regarded as the remains of the cranial extremity or infundibulum. In the female, however, the Müllerian ducts undergo further differentiation; the cranial extremities remain separated, maintain their communication with the abdominal cavity, and become the *tubæ uterinæ* (*Fallopian tubes*), while the caudal extremities become fused for a considerable distance and their walls undergo further development and differentiation to form the *uterus* and the *vagina* (see page 147 *et seq.*).

In both sexes the genital gland likewise arises from the cœlomic epithelium. It forms the *testis* in the male and the *ovary* in the female. The indifferent genital gland may consequently become either a testis or an ovary, while the Wolffian duct becomes the excretory duct of the genital gland in the male, and the Müllerian duct atrophies, the reverse condition obtaining in the female.

The first indication of the permanent kidney arises very early (fifth week) in the human embryo as a blind protrusion from the lower extremity of the Wolffian duct just before its termination in the allantois. This protrusion forms the *renal canal*, *i. e.*, the rudiment of the ureter and of the renal pelvis. Recent investigations have shown, however, that the uriniferous tubules of the permanent kidney are developed almost throughout their entire extent from a mass of mesodermal tissue, the *metanephric blastema*, which is quite distinct at first from the renal canal, although union of the tubules formed from the blastema and the canal occurs quite early. It is not improbable that the blastema may be a derivative of the embryonic tissue which gives rise to the Wolffian body.

Since the Wolffian ducts, the Müllerian ducts, and the ureters (through the Wolffian ducts) all terminate in the allantois which is a protrusion of the hindgut, the entire urogenital apparatus of the fetus is connected with that lowermost portion of the hindgut which is closed by the cloacal membrane (see page 21). In the human embryo the allantois is a rudimentary structure; it gives off a prolongation, the *urachus*, which passes into the umbilical cord, where it terminates blindly, and subsequently by the obliteration of its lumen forms the *middle umbilical ligament* (see page 121), while the remaining intra-embryonic portion of the allantois practically forms the bladder. The terminal portion of the intestinal canal with which the allantoic diverticulum is connected, and which is at first closed by the cloacal membrane, is known as the *cloaca* (Fig. 465). It is a common cavity for the termination of the intestinal tract and for the excretory ducts of the urogenital apparatus, and after the disappearance of the cloacal membrane it opens externally, so

that both the intestine and the entire urogenital system have a common opening, the *cloacal opening*.* The cloaca soon becomes subdivided by a partition, the *perineum*, which separates the hindgut from the urogenital system and the hindgut then terminates at the anus, while the urinary and sexual organs empty into the urogenital sinus, which is separated from the anus by the perineum. The urogenital sinus receives the Müllerian and Wolffian ducts or that portion of these structures remaining after the sexual differentiation which has already taken place (see page 126) and, in the female, it also receives the short narrow excretory duct (the urethra) from the bladder which has developed from the allantois, and in the male the analogous portion of the urethra opens into it above the orifices of the sexual ducts. This condition is practically a permanent one in the female, since the urogenital sinus is transformed into the vestibule of the vagina, but in the male the urogenital sinus becomes converted into the greater portion of the urethra when the external genitalia are developed.

There is also an indifferent stage in the development of the external genitalia. The first rudiment of these structures appears in front of the cloacal membrane as a conical elevation known as the *genital tubercle* (Fig. 465). Upon this tubercle on the surface toward the cloacal membrane there is a cleft, the *genital groove*, which is bounded upon either side by the *genital folds*, and parallel to these folds are two cutaneous elevations, the *genital swellings* (*tori genitales*), which unite in front of the genital tubercle and gradually disappear as they extend posteriorly toward the subsequent anal orifice. In the female, the genital tubercle forms the *clitoris*, the genital swellings the *labia majora*, the genital folds the *labia minora*, and the urogenital sinus opens at the genital groove. In the male the rudiments of the external genitalia undergo much more marked changes in their transformation into permanent structures. The genital swellings fuse to form the *scrotum*, the raphe remaining at the line of fusion; the genital tubercle forms the *penis;* and the genital groove becomes closed in by the fusion of its lips, except at the urethral orifice, by which the urogenital sinus opens externally. Owing to the growth of the penis the urogenital sinus becomes markedly elongated, forming a considerable portion of the urethra, and the genital folds form the frenulum of the glans. Defects upon the lower surface of the penis are explained as an imperfect fusion of the lips of the genital groove.

The Wolffian body and the genital gland are originally situated upon the posterior abdominal wall in what subsequently becomes the renal region. In both sexes a downward movement occurs which is designated as the descensus ovariorum or testiculorum as the case may be. This occurs partly as a result of unequal growth and partly as a consequence of the muscular traction of a structure which is at first attached to the Wolffian body and extends to the region of the subsequent inguinal canal. This structure is at first termed the *inguinal ligament* of the Wolffian body, but later it proceeds from the lower extremity of the genital gland, and is then known as the *gubernaculum testis* or *ovarii* (*gubernaculum of Hunter*). In the female the genital gland descends only into the pelvis, where the inguinal ligament becomes the ovarian and round ligaments. In the male the change in the position of the genital gland, is much more marked, since the testis, together with a peritoneal diverticulum, the *inguinal cone*, is drawn through the inguinal canal and down into the scrotum by the gubernaculum. The portion of the

* In the human embryo the cloacal membrane does not disappear until after the cloaca has been subdivided, and the urogenital sinus has an external orifice before the anal opening is completed.

inguinal cone outside the abdominal inguinal ring is termed the *vaginal process* of the peritoneum. The testis and vaginal process in their descent push ahead of them the cremasteric fascia (see page 133), the musculature of the obliquus internus as the m. cremaster (see page 133 and Vol. I, page 160), and the transversalis fascia (as the tunica vaginalis communis), and naturally take along the vessels and nerves of the testis, as well as its excretory duct, the vas deferens, this latter structure, together with the vessels and nerves, forming the *spermatic cord*. The descent of the testis is gradually accomplished and is not completed until during the last month of fetal life. Outside the inguinal canal the vaginal process of the peritoneum becomes obliterated throughout the spermatic cord and forms a fibrous cord, the rudiment of the vaginal process, but it persists within the scrotum, forming a peritoneal investment for the testis, the *tunica vaginalis propria*.

The remaining portions of the genital system, such as the glands, are formed secondarily in the usual way. The indifferent rudiments consequently correspond to the following structures in the two sexes:

Indifferent Embryonic Condition.	Male.	Female.
Germinal gland	Testis.	Ovary.
Wolffian body:		
Proximal portion	Epididymis.	Epoöphoron.
Distal portion	Paradidymis.	Paroöphoron.
Inguinal ligament of Wolffian body	Gubernaculum testis.	Ovarian ligament and round ligament of uterus.
Wolffian duct	Vas deferens.	Disappears completely.
Müllerian duct	Prostatic utricle (appendix testis).	Fallopian tubes, uterus, and vagina.
Genital tubercle	Penis.	Clitoris.
Genital folds	Frenulum glandis.	Labia minora.
Genital swellings	Scrotum.	Labia majora.
Urogenital sinus	All of urethra except the first portion.	Vestibule of vagina.
	Bulbourethral glands.	Greater vestibular glands.
	Corpus cavernosum.	Bulbus vestibuli.
	Prostate gland.	Rudiments.
	Seminal vesicles.	

THE MALE SEXUAL ORGANS.

The male sexual organs (Figs. 480 to 483) include the *testis*, the *epididymides*, the *vasa deferentia*, the *seminal vesicles*, the *prostate gland*, the male *urethra*, the *spermatic cord*, the *bulbo-urethral glands* (*glands of Cowper*), the *penis*, and the *scrotum*.

The Male Internal Genitalia.

The internal genitalia of the male are not sharply differentiated from the external parts. They consist of the testis, the epididymis, the vas deferens and the spermatic cord, the seminal vesicles, the prostate gland, the bulbo-urethral glands (glands of Cowper), and a portion of the male urethra.

THE TESTIS AND EPIDIDYMIS.

The **testis** (Figs. 484 to 488) is a paired, ellipsoidal glandular body, slightly flattened from side to side. It is of a bluish-white color and is situated within a serous sac in the scrotum. It

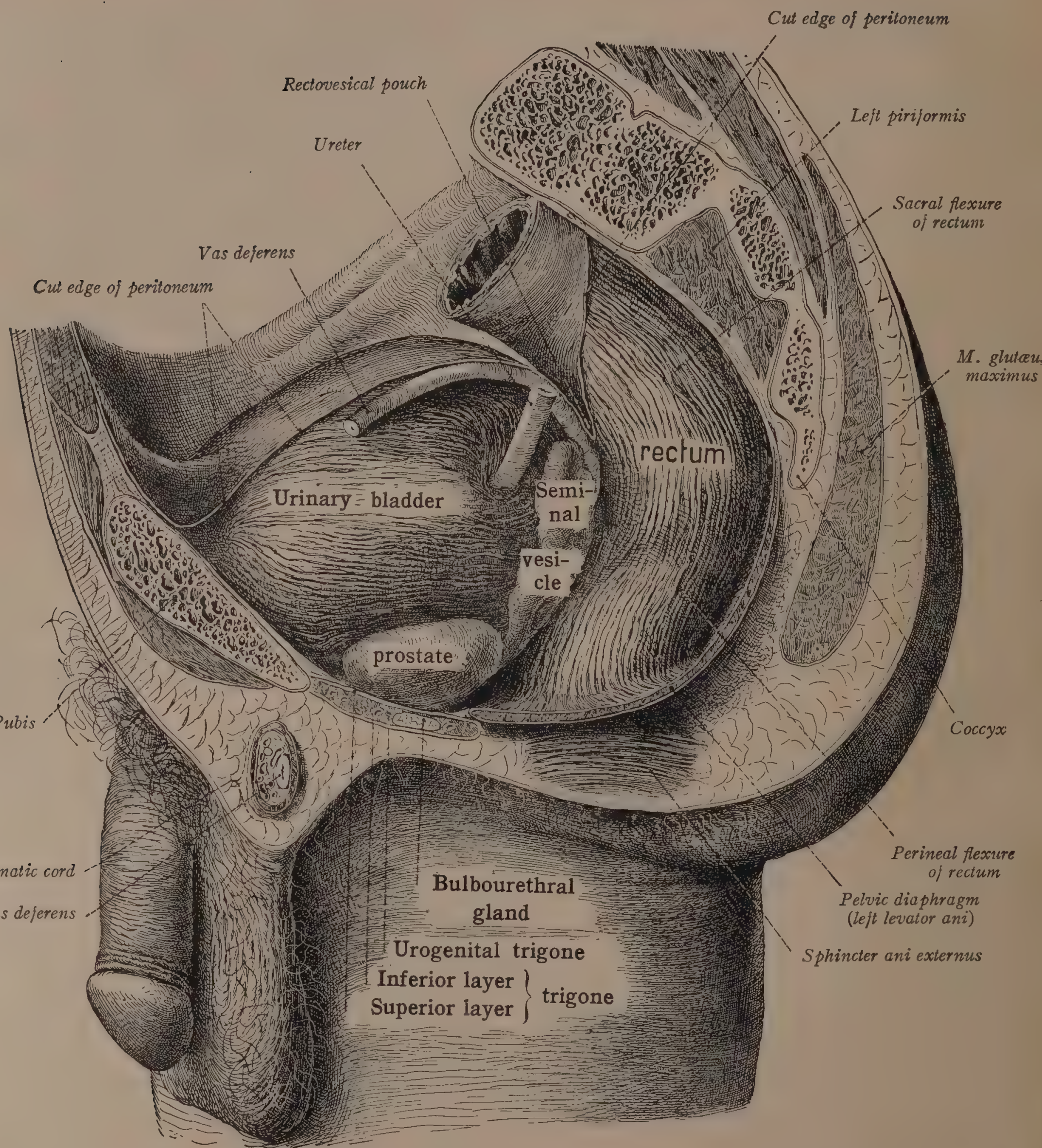
presents a *superior* and an *inferior extremity* and *external* and *internal surfaces*. The internal surface is somewhat flattened and is separated from the external one by the markedly flattened *anterior* and *posterior borders*, which are really narrow surfaces, the entire surface of the testis being convex and very smooth. The axis of the testis passes obliquely from above downward, from before backward, and from without inward, and consequently the anterior border is directed somewhat backward and the posterior one slightly upward, while the internal surface looks somewhat anteriorly and the external posteriorly.

In addition to the visceral layer of the tunica vaginalis, the testis is also enclosed by a firm white fibrous capsule, the *tunica albuginea* (Fig. 487), which gives the organ its whitish appearance and solidity. It becomes thin at the posterior border of the testis, where it is perforated by the vessels and nerves passing into the interior of the viscus. The posterior border is consequently attached, while the anterior is free, and the posterior border is also continuous with a wedge-shaped mass of connective tissue which is triangular in cross-section, the *mediastinum of the testis* (*corpus Highmori*) (Figs. 487 and 488). The narrow anterior border of this projects into the interior of the testicle and the entire structure is traversed by vessels and seminal tubules, and is considerably shorter than the testicle, so that it gradually disàppears as it approaches the upper and lower extremities of the organ. It gives off fibrous partitions known as the *septula of the testis*, which radiate toward the inner surface of the tunica albuginea, and between these septula are situated the individual lobules of the parenchyma of the viscus, which are broad at the tunica albuginea and pointed at the mediastinum.

The lobules of the testis contain the actual secreting canals of the viscus, the *tubuli seminiferi contorti*, fine, long, white, markedly convoluted tubules which are distinctly visible to the naked eye (Fig. 486). In the region of the mediastinum they become continuous with much narrower, straight tubules, the *tubuli seminiferi recti*, which anastomose with each other in this situation, forming the *rete testis* (*rete Halleri*), and from the base of the mediastinum ten to fifteen excretory ducts, the *ductuli efferentes*, pass to the epididymis.

The **epididymis** (Figs. 484 to 488) is an elongated, retort-shaped body, the greatest length of which is applied to the posterior border of the testicle. In its middle portion it is shaped like a three-sided prism, and its upper extremity is thickened and rounded. Three parts, which are not sharply defined, may be recognized in the epididymis: (1) the *head* or *caput*, (2) the *body* or *corpus*, and (3) the *tail* or *cauda*. The upper extremity of the markedly thickened *caput* is rounded and directed internally, and its lower concave surface is applied to the tunica albuginea of the superior extremity of the testicle. The *body* is usually the thinnest portion of the structure and is distinctly prismatic; its anterior border is firmly adherent to the posterior border of the testis and the contiguous portion of the external surface, but the remaining portions of it merely rest upon the testis, from which they are separated by the *sinus of the epididymis*. The more rounded and curved *cauda* is usually thicker than the body; it is situated at the inferior extremity of the testis, where it makes a sharp bend to become continuous with the vas deferens, which passes upward.

The epididymis is longer than the testis and rather markedly curved. It is not situated exactly posteriorly but also somewhat externally (particularly the body). The convex surface of its head, the entire external surface and a portion of the anterior surface of the body, and the ex-



FIGS. 480 and 481.—The male genitalia seen in profile. The sacrum and coccyx and the pubis have been divided near the middle line and the peritoneum dissected away from the lateral surface of the bladder.

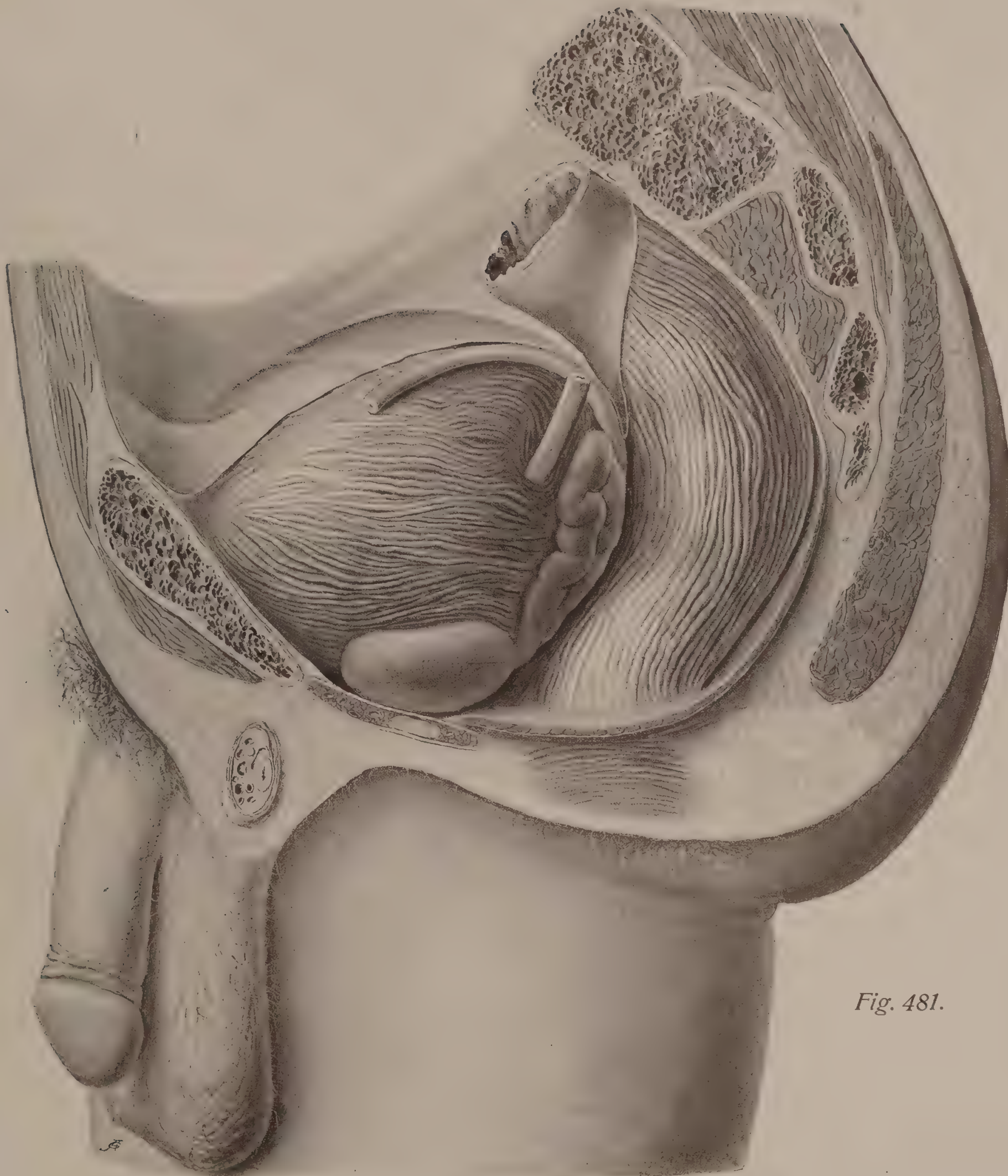


Fig. 481.

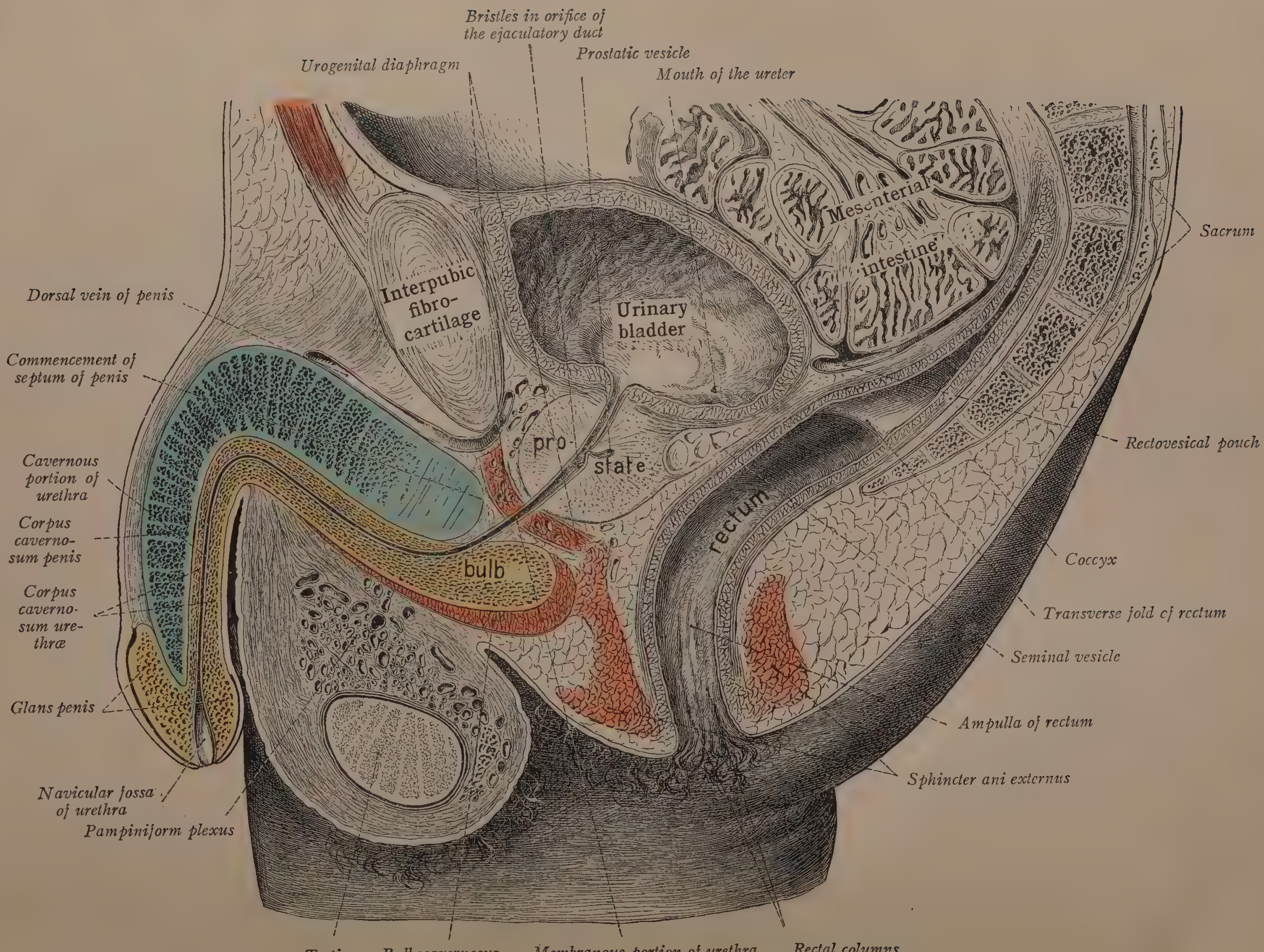
ternal surface of the tail are invested by the visceral layer of the tunica vaginalis. Its surface in general is smooth, but the head exhibits small, irregular, transverse grooves, and the entire structure is also surrounded by a tunica albuginea which is considerably thinner than that of the testis.

The head of the epididymis contains the conical *lobuli*, which correspond in number to the ductuli efferentes of the testis with which they are continuous by their apices. The ductuli efferentes are coiled up in the lobules of the epididymis, and while still within the head of epididymis empty into a very long cylindrical canal known as the *duct of the epididymis*. This is thrown into an extremely large number of compact convolutions with acute flexures, and forms the entire body and tail of the epididymis, its convolutions being held together by fasciculi of connective tissue, and at the end of the tail it becomes continuous with the vas deferens, there being no sharp demarcation between the two structures.

The testis and the epididymis together form what is termed the testicle. They lie in a serous cavity formed by the *tunica vaginalis propria* (Figs. 484, 485, and 490), which arises in the fetus as a peritoneal diverticulum, but subsequently becomes completely cut off from the peritoneum and forms a paired cavity situated within the scrotum (see page 139). Like other serous sacs it possesses a parietal and a visceral layer. The testis and epididymis push the visceral layer before them in such a way that the testis is entirely enveloped by it except in the region where the vessels enter, and the epididymis is also partially covered. In this manner two serous folds are formed between the testicle and the epididymis, one at the base of the head of the epididymis, the *superior ligament of the epididymis*, and the other at the junction of its body and tail, the *inferior ligament of the epididymis*. These ligaments form the boundaries of a cleft-like space situated between the testis and the epididymis and termed the *sinus of the epididymis*. The relatively large cavity of the tunica vaginalis propria contains several drops of a serous fluid.

The testis and epididymis almost always possess several appendages which are also covered by the visceral layer of the tunica vaginalis. As a rule, both the testis and the epididymis (head) possess such structures, but only the *appendix testis* (*hydatid of Morgagni*) (Figs. 484 and 485), the so-called non-pedunculated hydatid, is constant. It rests upon the upper extremity of a testis where it is covered by the epididymis, and is a semisolid, elongated and flattened, club-shaped body covered by ciliated epithelium, and is regarded as the homologue of the abdominal orifice of the Fallopian tube. The *appendix of the epididymis* (Figs. 484 and 485), the so-called pedunculated hydatid, is not always present. It is an elongated vesicle which is attached to the head of the epididymis by a short pedicle, and, like the superior ductulus aberrans (see below), seems to be an undeveloped lobule of the epididymis.

Just above the head of the epididymis in the spermatic cord is situated the *paradidymis*, the remains of the distal portion of the Wolffian body; it is a small elongated structure consisting of a number of slightly tortuous canals and is only demonstrable during childhood. It must not be confounded with the *superior ductulus aberrans*, a very inconstant, isolated, blind lobule of the epididymis, which communicates directly with the testis. The *inferior ductulus aberrans* (Fig. 486) is more frequently present; it is attached to the tail of the epididymis and is the remains of a tubule of the Wolffian body. It passes upward for some distance alongside the body of the epididymis as an elongated blind appendage.



FIGS. 482 and 483.—Median section of the male pelvis and genitalia. (In Fig. 483 the corpus cavernosum of the penis is blue, and the corpus cavernosum of the urethra yellow.)

Fig. 482.

The arteries of the testis (and of the epididymis) are the testicular, the terminal branch of the spermatic, and the artery of the vas deferens which is derived from the internal iliac. Both of these arteries pass to the testis through the spermatic cord, and their length and the high origin of the testicular artery (from the abdominal aorta) are explained by the descent of the testes (see page 127). While the testicular artery supplies the entire testis and the head of the epididymis, the artery of the vas deferens passes to the body and tail of the epididymis and anastomoses with the former vessel.

The veins of the testis and epididymis form the pampiniform plexus upon the posterior surface of the testis and in the spermatic cord; this plexus becomes continuous with the testicular vein (internal spermatic) and some of the posterior veins of the testis empty into the inferior epigastric vein.

The numerous lymphatic vessels of the testis pass upward with the veins in the spermatic cord and terminate in the lumbar lymphatic glands.

The nerves of the testis are derived from the sympathetic and form a plexus along the artery in the spermatic cord.

THE VAS DEFERENS, THE SEMINAL VESICLE, AND THE EJACULATORY DUCT.

The **vas deferens** (*ductus deferens*) (Figs. 412, 413, 478, 481, 486, 489, and 490) is the actual excretory duct of the testis. It is an almost perfectly cylindrical canal, about forty centimeters in length, which arises at the lower pole of the testis as a direct continuation of the tail of the epididymis (Fig. 486). It runs upward parallel to the epididymis, enters the spermatic cord, passes through the inguinal canal with the latter structure (Fig. 490) and, after dilating to form the ampulla, unites with the seminal vesicle (Fig. 489) and empties into the prostatic portion of the urethra.

The vas deferens commences at the lower end of the duct of the epididymis by the lumen of the latter becoming much narrower, while its wall becomes considerably thicker. The wall consists of a thin mucous coat, of a very strong muscular coat, the structure of which varies somewhat in different situations, but which is made up of an external, middle, and internal layer, and of an outer coat which is essentially fibrous in character. The muscular coat is relatively the strongest involuntary muscle of all the male viscera and the vas deferens in consequence feels like cartilage.

The vas deferens at its commencement is situated at the posterior border of the testicle and it pursues an almost straight or slightly tortuous course to the upper pole of the organ, where it makes quite an obtuse angle and enters the *spermatic cord.*

This (Figs. 413 and 490) is a cylindrical structure of rather soft consistency, which is about as thick as the little finger and 15 to 20 cm. long. It extends from the abdominal inguinal ring * (see page 82) to the posterior border of the testis, and its chief constituents are the vas deferens, the testicular artery, and the wide-meshed pampiniform plexus. With these structures are associated the artery and vein of the vas deferens, the lymphatics and nerves of the testis (spermatic plexus), and the nerves of the vas deferens. The vessels for the testis are grouped in the antero-external portion of the cord, while those for the vas deferens are situated posteriorly and to the inner side. The spermatic cord also contains the rudiment of the vaginal process (see page 128) and, in its lower portion, the paradidymis (see page 131), and nonstriated musculature known as the *m. cremaster internus* is also present. All these structures are surrounded by loose connective tissue poor in fat, by the *m. cremaster externus* (see pages 128, 139, and Vol. I, page 160), the *cremasteric fascia* (see page 139), and the *tunica vaginalis communis.*

The vas deferens passes through the inguinal canal in the spermatic cord and reaches the

* Since some of the coverings of the cord are derived from the interior of the inguinal canal and from the subcutaneous inguinal ring, the structure is not complete until it reaches the latter point.

FIG. 484.—The testis and epididymis with their investing membranes seen from in front.

FIG. 485.—The testis and epididymis with their investing membranes seen from the lateral surface.

FIG. 486.—The testis, epididymis, and the proximal portion of the vas deferens.

The tunica albuginea has been completely removed from the epididymis and partly from the testis; the tubuli contorti of the lowest lobule of the testis have been isolated.

FIG. 487.—Longitudinal section of the testis and epididymis.

FIG. 488.—Transverse section of the scrotum and the two testes.

* = Cavity of the tunica vaginalis propria.

FIG. 489.—The prostate and the seminal vesicles seen from above and in front.

The left seminal vesicle together with the ampulla of the vas deferens has been divided longitudinally and the urethra has been cut off close to its exit from the bladder.

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abdominal inguinal ring. Here it lies immediately in front of the parietal peritoneum, and after accompanying the internal spermatic vessels for a short distance, it descends into the true pelvis (Fig. 412). This part of the vas is accordingly termed the *pelvic portion*, in contradistinction to the *inguinal portion*, which is situated within and in front of the inguinal canal. The vas deferens suddenly leaves the spermatic vessels and descends upon the lateral wall of the pelvis almost to the pelvic floor, being still covered throughout by the parietal peritoneum. It then passes downward, backward, and inward to the side of the fundus of the bladder, where it is closely applied to the vesical wall and covered by the visceral layer of the peritoneum, and at the lower portion of the posterior wall of the bladder, at the junction of the body with the fundus, it crosses the lower portion of the ureter and takes up a position in front and to the inner side of this structure (Fig. 478).

Below this crossing and before reaching the prostate the terminal portion of the vas exhibits a rather marked spindle-shaped dilatation known as the *ampulla* (Figs. 478 and 489). The external surface of this structure is not smooth but slightly indented, and the internal surface possesses numerous folds of mucous membrane which project deeply into the lumen and undergo manifold subdivisions and anastomoses, so that there are formed deep, irregular, pouch-like depressions on the interior of the ampulla, the *diverticula of the ampulla*. The caliber of the ampullæ diminishes as they pass downward; they lie immediately alongside the seminal vesicles (Figs. 478 and 489), their lower portions being only a few millimeters from the median line. The largest diameter of the ampullæ is about one centimeter and they are from three to four centimeters in length.

The **seminal vesicles** (Figs. 478, 481, and 489) are elongated culs-de-sac, flattened from before backward, which are attached to the vasa deferentia upon either side at the termination of their ampullæ. They are about 4 or 5 cm. long, 2 cm. broad, and 1 cm. thick. The upper extremity broadens out to form the *body* (*corpus*), and the lower extremity becomes contracted to form a short *excretory duct*. The surface is irregularly nodular. The vesicles are intimately adherent to the postero-inferior wall of the bladder above the prostate, just to the outer side of the ampullæ of the vasa deferentia (Fig. 478); their blind extremities are placed immediately to the inner side of and below the entrances of the ureters into the bladder, and by their posterior surfaces they are in relation with the anterior rectal wall, from which they are separated by fatty tissue and peritoneum. About the upper third of each vesicle is covered by peritoneum, so that a portion of the rectovesical pouch is situated between them and the rectum.

The seminal vesicles and the immediately contiguous ampullæ are surrounded by a common

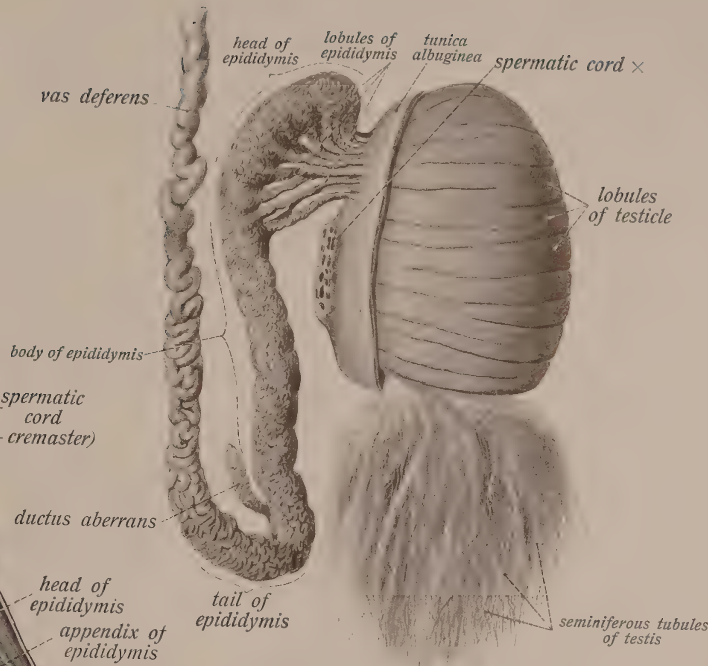

Fig. 486.

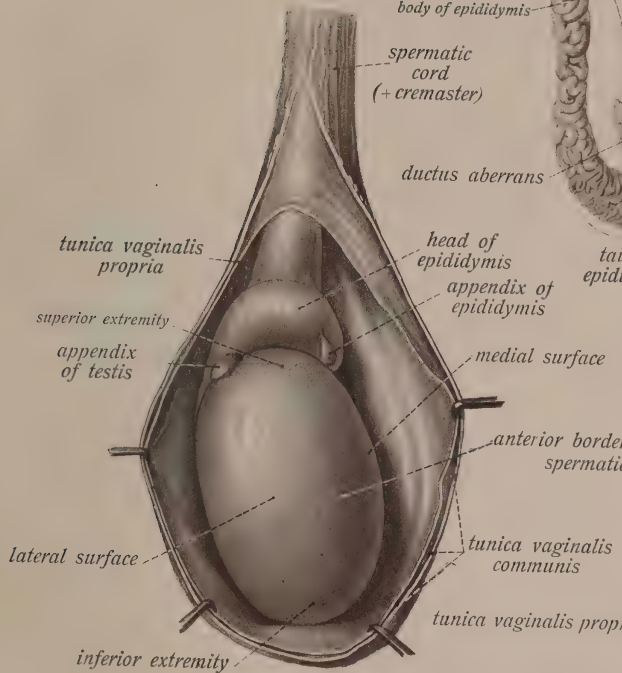

Fig. 484

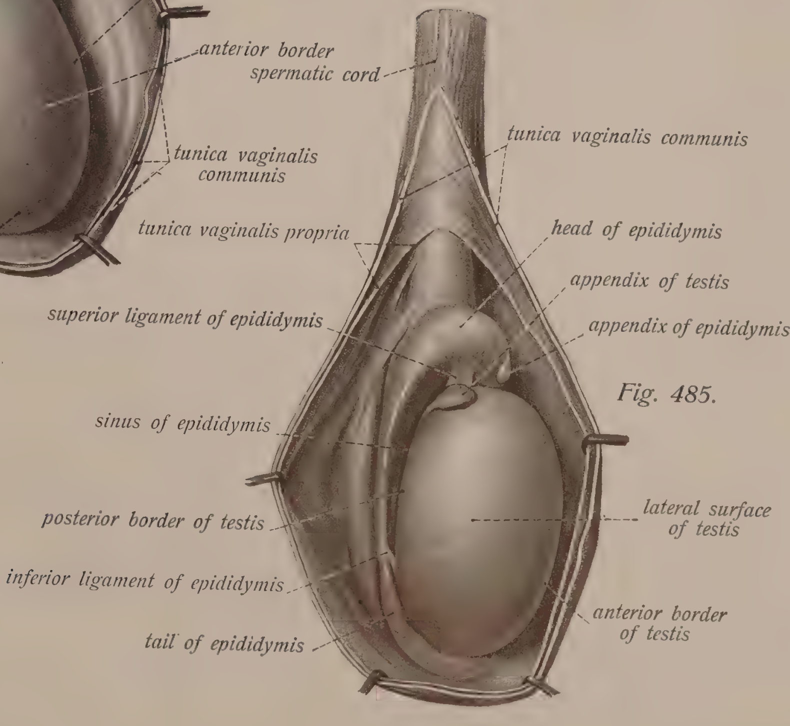

Fig. 485.

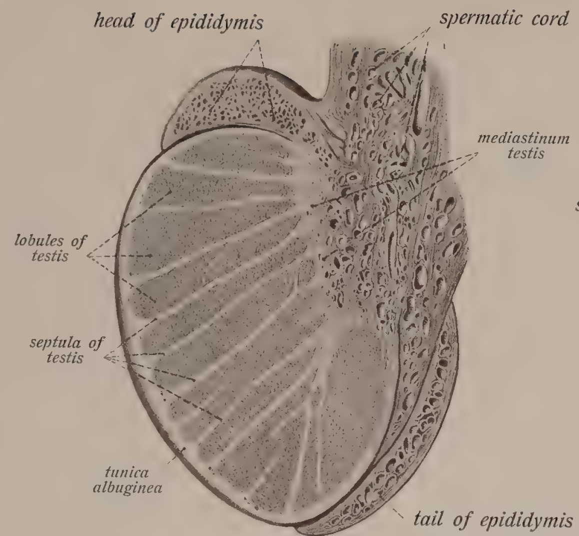

Fig. 487.

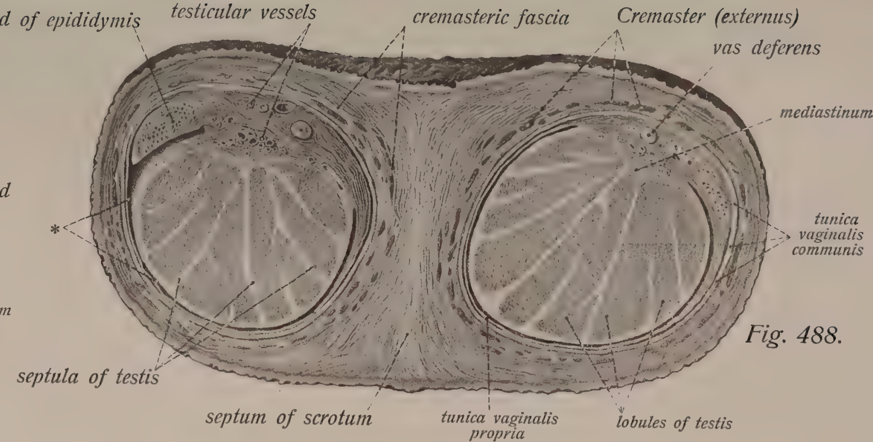

Fig. 488.

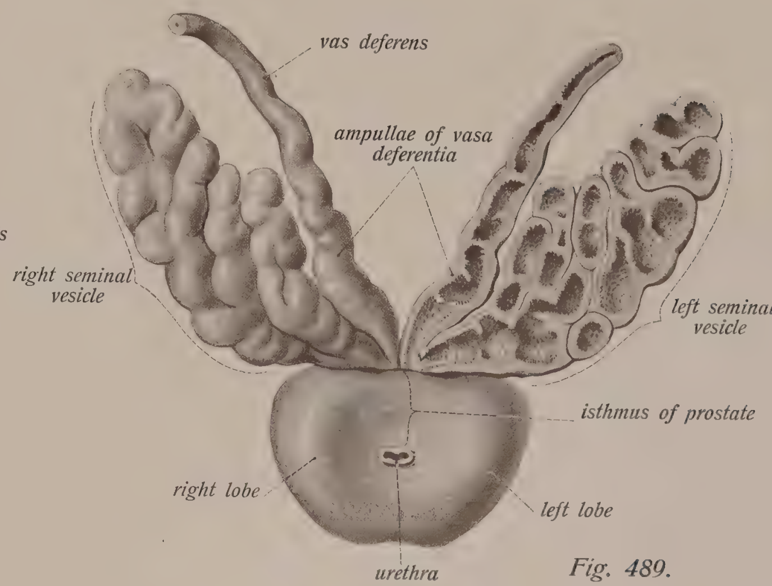

Fig. 489.

fibrous capsule. Their lower extremities converge until they are in contact, but the superior extremities of the seminal vesicles are separated from each other by a distance of about six centimeters.

Each seminal vesicle practically consists of a single wide tortuous canal provided with blind diverticula, the convolutions of which are firmly bound together by connective tissue (Fig. 489). In other respects the seminal vesicle resembles the ampulla of the vas both in its macroscopic and microscopic appearance.

By the junction of the excretory duct of the seminal vesicle with the ampulla of the vas there is formed a short narrow canal, the **ejaculatory duct** (Figs. 476 and 479), which traverses the prostate and by means of which the vas and the seminal vesicle open into the urethra. This junction takes place at an acute angle (Fig. 489) and the lumen of the ejaculatory duct is at first relatively large; within the prostate it becomes considerably narrower and at its termination the caliber is about 0.15 cm. Almost the entire ejaculatory duct is situated within the prostate, which it traverses obliquely in such a manner that the walls of the duct are fused with the prostatic tissue and situated in the immediate vicinity of the prostatic utriculus. Both ejaculatory ducts converge toward the middle line and terminate close together in the urethra upon the colliculus seminalis (see page 137).

The vas deferens is supplied by the artery of the vas from the internal iliac (directly or indirectly); the arterial branches for the seminal vesicles and the ampullæ of the vasa deferentia are derived partly from the artery of the vas and partly from the inferior vesical and middle hemorrhoidal arteries.

The veins of the vas are connected partly with the pampiniform plexus and partly with the plexus venosus seminalis, with the veins of the bladder, and with the vesicoprostatic plexus. The veins of the seminal vesicle form an individual plexus which is named after this structure. The lymphatic vessels of the vas deferens are associated with those of the spermatic cord which pass to the lumbar glands and with those of the seminal vesicle which run to the hypogastric glands.

The nerves of the vas deferens and of the seminal vesicle are derived from the hypogastric plexus of the sympathetic.

THE MALE URETHRA, THE PROSTATE, AND THE BULBO-URETHRAL GLANDS.

The **male urethra** (Figs. 476, 482, 483, 491, and 492) is an S-shaped canal, 18 to 22 cm. in length, which commences at the bladder (see page 122) and terminates at the end of the penis at the external orifice. Only that portion which extends from the internal orifice to the colliculus seminalis serves purely as a urinary passage and corresponds to the female urethra (see page 127); the greater portion by far, situated anterior to the colliculus, serves both as a urinary and a seminal passage. In the male urethra three portions: the *prostatic*, the *membranous*, and the *spongy* may be recognized (Figs. 482 and 483).

The **prostate** (Figs. 476, 478 to 483, 489, 491, and 492) is a glandular, muscular organ, situated at the lower end of the bladder, and of a shape which is usually compared to that of a chestnut. The broad upper portion adherent to the bladder is termed the *base*, while the markedly rounded tip, directed downward and forward, is the *apex*. A shallow groove upon the posterior surface of the organ indicates two incompletely separated *lobes*.

The base of the prostate is divided into an anterior and a posterior portion by a transverse groove produced by the entrance of the ejaculatory ducts. The anterior portion is designated as the *isthmus* of the prostate (Fig. 479) and is firmly attached to the bladder, while the posterior

portion is in contact with the ampullæ of the vasa deferentia and the apices of the seminal vesicles. Occasionally the isthmus is more markedly developed and projects against the postero-inferior wall of the bladder, and it is then known as the *middle lobe*.

The almost plane and longer posterior surface of the organ is inclined, while the much shorter anterior surface is almost vertical, the two surfaces, however, not being sharply defined, but joined by lateral convex borders. The prostate is distinctly flattened from before backward, so that the transverse diameter is usually the greatest.

It is traversed by the prostatic portion of the urethra (Figs. 482 and 483) in such a manner that this structure is nearer the anterior than the posterior wall. The slightly concave base is directed upward and is firmly adherent to the fundus of the bladder, the posterior wall is in relation with the anterior rectal wall, with which it is connected by the fibrous fasciculi of the rectovesical fascia, and the apex is intimately united with the urogenital trigone. The anterior surface is attached to the anterior wall of the pelvis by a median and two lateral ligaments, which are termed the *median* and *lateral puboprostatic ligaments* and are situated behind the lower portion of the pubic symphysis. The lateral surfaces of the prostate are in relation with the levator ani muscles. Several venous plexuses are situated in the vicinity of the prostate; in front is the pudendal plexus, and at the base and to either side is the vesicoprostatic plexus.

The prostate is made up of involuntary muscle and of glandular tissue, sometimes one and sometimes the other element preponderating. The lateral portions of the prostate and the larger portion situated behind the urethra are rich in glandular elements, while the narrow portion in front of the urethra contains but few of these constituents.

The entire glandular mass of the prostate is termed the *corpus glandulare*. It consists of a large number of individual glands, whose excretory ducts are known as the prostatic ducts. These open separately or in combination with each other by about thirty narrow orifices in the prostatic portion of the urethra, and corresponding to the preponderance of the glandular tissue in the posterior segment of the prostate, these orifices are situated principally in the posterior portion of the urethral wall, especially at either side of the colliculus seminalis.

The prostatic musculature is chiefly involuntary in character, but at the lower extremity of the organ it becomes intermingled with the striated fibers of the *sphincter urethræ membranaceæ*. The proper prostatic musculature is termed the *m. prostaticus;* at the base of the prostate it is connected with the urethral annulus (sphincter vesicæ, see page 123) and consists of irregularly arranged muscular fasciculi, the majority of which pass transversely and surround the gland.

The fibrous capsule which envelops the prostate and is particularly developed laterally and posteriorly, is known as the *prostatic fascia* (see page 162); it is thickest upon the posterior surface of the organ, where it is connected with the rectovesical fascia.

The *prostatic portion of the urethra* (Figs. 476, 482, and 483) is in the anterior portion of the prostate; superiorly is it situated approximately at the junction of the anterior and middle thirds, while inferiorly at the apex of the gland it is almost exactly in the middle. It is 2 to 2.5 cm. long and pursues an almost vertical course, though slightly convex posteriorly. The mucous membrane is firmly attached to the rather unyielding prostatic substance, so that this portion of the urethra is of large and constant caliber.

Upon the posterior wall of the prostatic urethra there is a longitudinal fold known as the

urethral crest (Fig. 476), which commences at the internal urethral orifice as a continuation of the uvula of the bladder and extends into the membranous urethra or even beyond this point. At about the middle of the prostatic urethra the urethral crest is elevated to form a longitudinal ridge about three millimeters in height, the *colliculus seminalis* (verumontanum), which projects into the lumen of the urethra in such a manner as to produce two deep lateral grooves (*lateral sulci of the colliculus*). The colliculus consists not only of mucous membrane but also of prostatic tissue, and particularly of its glandular element, so that the structure is to be regarded as a protuberance of the prostatic substance covered by the urethral mucous membrane.

The top of the colliculus seminalis presents a fine slit-like orifice which leads into a cul-de-sac within the prostatic tissue, the *prostatic utriculus*, which represents a rudimentary uterus masculinus (see page 126), is of variable size and development, and usually appears as a flattened pear-shaped vesicle, directed backward and upward toward the base of the prostate. In rare cases it attains a considerable size.

To either side of the orifice of the prostatic utriculus, and usually somewhat posteriorly, upon the lateral slope of the colliculus is situated the small round opening of the ejaculatory duct. After entering the prostate (see page 135) this structure traverses the substance of the organ almost horizontally, and toward its termination converges slightly toward the median line. More rarely the ejaculatory ducts open into the prostatic utriculus or, by means of a common orifice, with this structure. Alongside the orifices of the ejaculatory ducts upon the lateral slopes of the colliculus and in the lateral sulci are found the numerous orifices of the prostatic ducts.

The prostatic urethra is continuous with the membranous urethra, which is so called since it is limited only by the urethral wall and the adjacent musculature, in contrast to the first portion of the urethra, embedded in the prostate, and the last portion, surrounded by the corpus cavernosum.

The *membranous portion of the urethra* (Figs. 482, 483, and 492) is short, being only about one centimeter in length. Like the prostatic portion, it runs almost vertically, although somewhat from behind forward and from above downward, presenting a slight concavity anteriorly and traversing the urogenital trigone (see page 162) in a rather oblique direction. Since the urogenital trigone is in contact with the inferior surface of the prostate, the urethra upon leaving the organ passes directly into the substance of this structure.

The muscular fasciculi of the m. trigoni urogenitalis (see page 159) form a circular ring of striated musculature about this portion of the urethra, and form what is known as the *sphincter urethræ membranaceæ*. The membranous portion is narrow but very dilatable, since its walls are isolated from the surrounding tissues and contain involuntary muscle, and its mucous membrane is characterized by a cavernous venous plexus.

To either side of the posterior portion of the membranous urethra and between the muscular fasciculi of the transversus perinei profundus (see page 159) are situated two small glands about the size of a pea; these are the **bulbourethral glands** (*glands of Cowper*) (Figs. 482, 483, 492, and 433). They are situated quite close to the median line, their internal margins being only several millimeters apart.

Each gland consists of a rather hard, nodular body and of an excretory duct. The latter is scarcely as thick as a knitting-needle and is rather long*; it passes forward and downward through

* The length is variable, but is usually several centimeters.

the bulb of the urethra to the commencement of the cavernous portion, where it opens upon the floor after perforating the mucous membrane at a very acute angle.

The *cavernous portion* (Figs. 482, 483, and 492) is by far the longest portion of the urethra and is situated throughout its entire length* within the corpus cavernosum. The superior portion is still vertical with a posterior convexity, and this is followed by the subpubic curvature, situated beneath the symphysis, the concavity of which is directed upward. This subpubic curvature is independent of the position of the penis (see page 139) and is consequently designated as the *fixed cavernous portion*, in contradistinction to the dependent portion in the flaccid penis, which is known as the *pendulous portion*. The cavernous portion consequently makes an S-shaped curve when the penis is not erect; when it is erect the inferior curvature disappears and the subpubic curvature alone remains. The length of the cavernous urethra is also dependent upon the condition of the penis; when the organ is flaccid this portion of the urethra is about 15 or 16 cm. in length, 7 to 9 cm. of which represents the pendulous portion. The caliber is uniform and of average width except just before reaching the meatus, where it is dilated, the dilatation being situated within the glans and being about two centimeters long; it is known as the *fossa navicularis* (*fossa of Morgagni*). The vertical diameter of this dilatation is greater than the transverse, and the narrowest portion of the urethra is at the meatus, which is a sagittal longitudinal fissure. The roof of the fossa navicularis frequently presents a transverse fold of mucous membrane, the *valve of the navicular fossa* (*lacuna magna* or *Guerin's fold*) (Fig. 492), and the mucous membrane of the cavernous urethra also possesses mucous glands which frequently empty into small recesses known as the *urethral lacunæ* (*lacunæ of Morgagni*). The commencement of the cavernous urethra also contains the orifices of the bulbourethral glands. When empty the lumen of the cavernous portion of the urethra is represented by a transverse slit, which in the posterior portion of the glans has a vertical branch which extends upward, while in the anterior portion of the glans (fossa navicularis) the transverse slit is replaced by a sagittal one.

The prostatic portion of the urethra is supplied by branches from the middle hemorrhoidal and inferior vesical arteries; the remaining portions are nourished by branches of the internal pudic (perineal, artery of the bulb, and urethral).

The veins of the upper portion of the urethra empty into the vesicoprostatic plexus, while those of the lower portion pass to the veins of the penis.

The lymphatic vessels of the urethra run to the hypogastric glands, partly also to glands in the inguinal region, and the nerves of the urethra are derived from the pudendal plexus, from the sacral plexus, and from the sympathetic (plexus prostaticus and cavernosus).

The Male External Genitalia.

THE SCROTUM.

The scrotum (Fig. 490) is a sac which is formed principally of the skin, and is to a certain extent unsymmetrical, in that its left half is usually longer than the right, corresponding to the lower position of the left testis. It contains both testes (and epididymides) with their serous sacs (see page 128), and the lower portions of the spermatic cords.

* A short portion (0.5 to 1 cm.) of the anterior wall of the urethra below the urogenital trigone is free from cavernous tissue, since the urethra enters the bulb quite gradually, the posterior portion having only a thin envelope of cavernous tissue.

The skin of the scrotum, which is directly continuous at its base with that of the mons pubis, perineum, and inner surface of the thighs, is characterized by a number of peculiarities. It is thin, distinctly pigmented and darker than the surrounding integument, contains large sebaceous glands and a scanty number of large isolated hairs, and its posterior portion presents a distinct ráphe which is continuous with that of the perineum, and represents the remains of the cleft between the rudimentary folds (see page 127) from which the scrotum is developed. The raphe corresponds to a *septum* (Figs. 488 and 492) in the interior of the scrotum, a partition formed of connective tissue, a little fat, and non-striated musculature, which separates the two testes and spermatic cords.

The integument of the scrotum contains a very extensive layer of non-striated muscle, which is arranged as a network of fasciculi and is known as the *dartos* (Fig. 490); by its contraction it produces the corrugation of the scrotal integument. Fatty tissue is entirely wanting in the skin of the scrotum, and beneath the dartos there is only a slight amount of areolar tissue.

Underlying the dartos is the *cremasteric fascia* (see page 133), which is reflected from the superficial abdominal fascia to the cremaster muscle and accompanies this into the scrotum. The muscle (see Vol. I, page 160) is a continuation of the obliquus abdominis internus, sometimes partly also of the transversus abdominis, and it extends downward into the scrotum as isolated fasciculi which are at first longitudinal and parallel and situated upon the posterior surface of the spermatic cord, but upon reaching the scrotum they surround the testis and its coverings and anastomose with one another, passing in transverse and oblique directions (Fig. 490).

The muscular fibers of the cremaster are in immediate contact with a layer of fascia, the *tunica vaginalis communis* (Figs. 484, 485, 488, and 492), so named because it belongs to both the testis and the spermatic cord. It is a continuation of the transversalis fascia of the abdomen and encloses the *tunica vaginalis propria*, which forms the innermost tunic of the testis (see page 131).

The scrotum consequently consists of the following layers: the integument with the dartos, the cremasteric fascia, the cremaster muscle, the tunica vaginalis communis, and the tunica vaginalis propria. The two testes are entirely independent of each other, each being situated in its own half of the scrotum, which is subdivided by the median septum. All the testicular coverings inside the dartos are similarly independent, and this independence extends, with the exception of small anastomoses, even to the blood-supply of the two viscera.

The arteries of the scrotal integument are the posterior scrotal branches of the internal pudic and the external pudic arteries, which are derived from the femoral and give off the anterior scrotal branches. The lateral portion of the scrotum also receives branches from the obturator artery.

The veins empty partly into the great saphenous through the external pudic veins, and partly into the internal pudic veins, and the nerves are the anterior scrotal branches from the external spermatic (lumbar plexus) and the posterior scrotal branches of the pudic.

THE PENIS.

The penis (Figs. 482, 483, and 490 to 497) is an almost cylindrical structure, whose *root* is attached to both pubic bones, and which when flaccid hangs downward, so far as its chief portion or body is concerned. Its free extremity forms the *glans*. The broad surface, which is directed upward and forward, is termed the *dorsal surface* (*dorsum penis*), and the somewhat narrower

FIG. 490.—The scrotum and spermatic cord seen from in front.

On the left side the crèmasteric fascia has been divided to expose the cremaster muscle; on the right all the investments of the spermatic cord have been divided and a window has been cut in the tunica vaginalis propria. The penis has been drawn upward and the fascia of the penis and the superficial perineal fascia have been partly removed so as to expose the anterior end of the bulbocavernosus.

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inferior and posterior surface the *urethral surface;* both of these are connected by lateral surfaces without demarcation.

The chief constituents of the penis are its erectile bodies, the corpora cavernosa, two of which, the *corpora cavernosa of the penis*, are paired, while the third, the *corpus cavernosum of the urethra*, is single.

The *corpora cavernosa of the penis* (Figs. 491, 492, and 494 to 497) are cylindrical structures the anterior and posterior extremities of which are pointed, and which are adherent to each other throughout the greater portion of their length. They arise from the inner margins of the inferior rami of the pubes by means of the *crura penis* (Fig. 492), which are slightly flattened and of a markedly diminished caliber. These structures converge along the lower margin of the pubis and gradually increase in size until they meet in front of the lower portion of the pubic symphysis, where they become adherent by their internal surfaces to form the *septum* of the penis (Figs. 494 and 495). They are firmly attached to the pubic bones by the albuginea (see below), and each has resting upon it the ischiocavernosus (see page 160) (Fig. 491).

By the adherence of the corpora cavernosa in the body of the penis there is formed in the dorsal portion of the organ a flattened cylindrical structure, the superior surface of which is smooth and traversed by the dorsal arteries and vein of the penis, while the inferior surface exhibits a broad deep groove, the *urethral sulcus*, which lodges the corpus cavernosum of the urethra (Fig. 494). The anterior extremities of the two corpora cavernosa of the penis are markedly pointed and project beneath the corona glandis (Fig. 491).

Each corpus cavernosum possesses an exceedingly firm and thick (about 2 mm.) fibrous capsule, known as the *tunica albuginea*, and in the body of the penis the two albugineæ are in contact in the median line and form the *septum of the penis* (Figs. 494 and 495), which is sometimes incomplete, so that the cavernous spaces of both erectile bodies are in communication. Within the albuginea is the actual cavernous tissue with its spaces and the numerous fine trabeculæ, which are attached to the inner surface of the albuginea. The deep vessels and the dorsal nerves of the penis run in the interior of the corpora cavernosa, usually near the septum.

The single erectile body of the penis, the *corpus cavernosum of the urethra* (*corpus spongiosum*) (Figs. 482, 483, 491, 492, and 494 to 497), is a distinctly flattened structure, the anterior and posterior extremities of which are greatly thickened. The posterior swelling is termed the *bulb*, the slender middle piece the *body*, and the anterior swelling the *glans*. The corpus cavernosum of the urethra is longer and thinner than that of the penis and its albuginea is much weaker, especially in the glans, but otherwise its structure is practically the same. With the exception of the bulb, it is traversed by the cavernous portion of the urethra (see page 138).

The *bulb* of the urethra (Figs. 482, 483, 491, and 492) is the club-shaped thickened posterior extremity of the corpus cavernosus of the urethra. It is approximately pear-shaped and about the

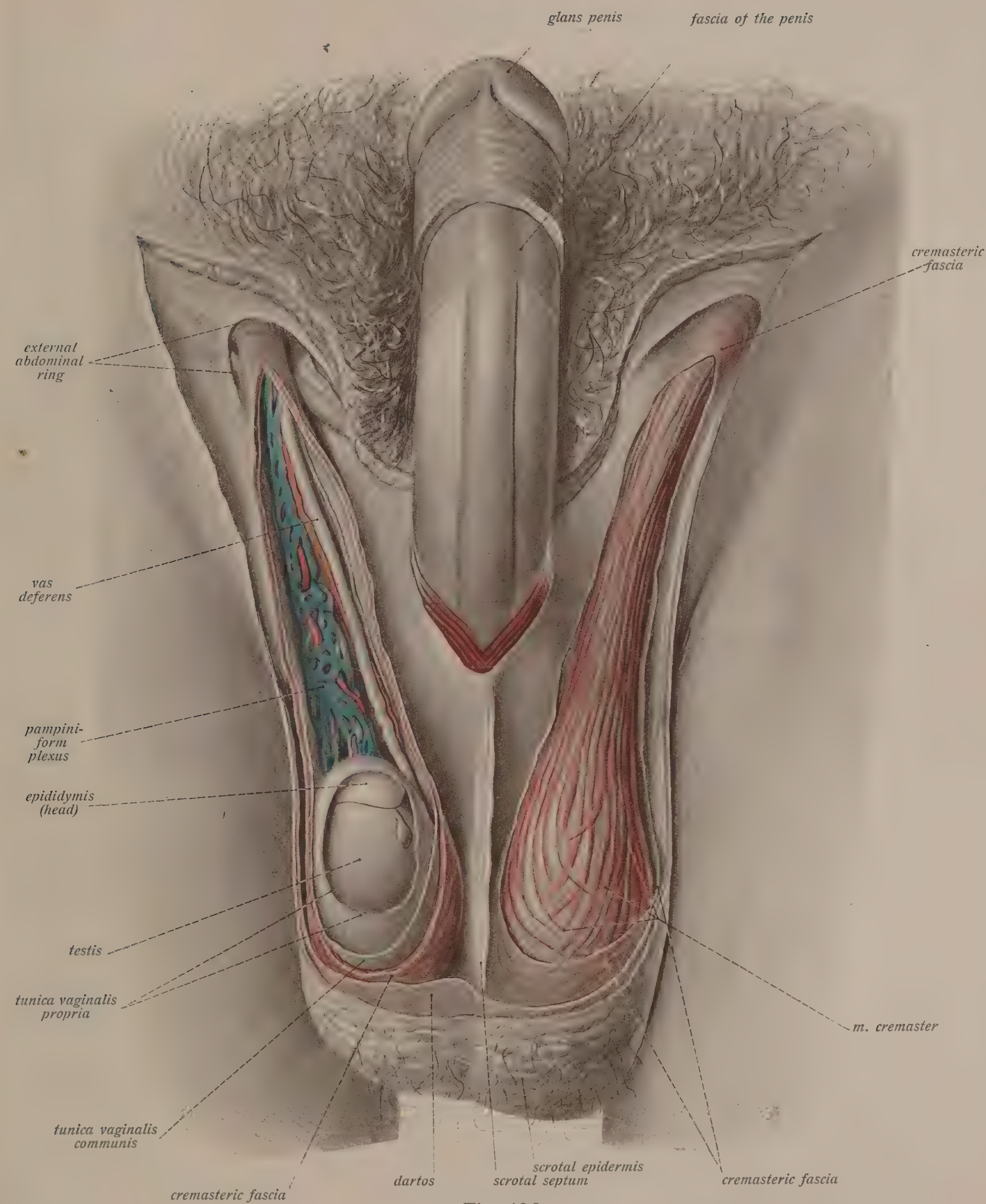
glans penis
fascia of the penis
cremasteric fascia
external abdominal ring
vas deferens
pampiniform plexus
epididymis (head)
testis
tunica vaginalis propria
tunica vaginalis communis
cremasteric fascia
dartos
scrotal epidermis
scrotal septum
cremasteric fascia
m. cremaster

Fig. 490.

size of a hazelnut, and presents a poorly developed *sulcus*, which indicates a separation of the bulb into two hemispheres (Fig. 492), these structures being more distinctly defined, however, in the interior of the bulb by the *septum* of the bulb. The bulb lies upon the inferior surface of the urogenital trigone, between the two crura, and is firmly adherent to the inferior fascia of the trigone. At the junction of its anterior extremity with the slender body of the corpus cavernosum of the urethra it is in relation with the membranous urethra, which enters the corpus cavernosum at this point, while the bulb remains unperforated. The inferior surface of the bulb is entirely covered by the bulbocavernosus (see page 160).

The long slender middle-piece or *body* of the corpus cavernosum of the urethra (Figs. 491, 492, and 494) is lodged in the urethral sulcus upon the inferior surface of the corpora cavernosa penis. It is markedly flattened in the dorsoventral direction and is rather firmly adherent to the albuginea of the corpora cavernosa penis. Its entire length gives passage to the cavernous urethra (see page 138), which is nearer its dorsal than its ventral surface.

The anterior enlargement of the corpus cavernosum of the urethra forms the *glans penis* (Figs. 491, 492, and 495 to 497), which is covered by very thin integument, firmly adherent to the exceedingly thin albuginea in this situation. The glans has the shape of a short, broad, oblique cone with a markedly round apex, its smooth convex dorsal surface being longer than the ventral (urethral) surface, which is provided with a shallow sulcus. The base of the glans is excavated, and its free rounded margin, known as the *corona glandis* (Fig. 491), overhangs the corpora cavernosa of the penis, which project into the excavation. The groove behind the corona is termed the *neck* of the glans (*sulcus retroglandularis*), and a fibrous partition, the *septum* of the glans (Fig. 497), extends upward from the lower surface of the albuginea to the urethra. The erectile tissue of the glans, the *corpus cavernosum of the glans*, is really an independent structure, the cavernous spaces of which, however, are in manifold communication with those of the corpus cavernosum of the urethra.

The three corpora cavernosa are enveloped by a common rather loose connective-tissue sheath which extends to the neck of the glans and is known as the *fascia of the penis* (Fig. 493). It also surrounds the dorsal vessels of the penis, and at the root of the organ it passes into the neighboring fasciæ without demarcation. The integument of the penis is destitute of hairs, rich in sebaceous glands, and free from fat; it is separated from the fascia penis by areolar tissue. At the root of the penis, hairs and fatty tissue make their appearance, and the integument assumes the character of that of the adjacent mons pubis.

The integument of the glans exhibits special characteristics (Figs. 482, 483, and 493). In this situation it forms a duplicature of varying length, the *prepuce*. The integument firmly invests the glans as far back as the neck, and is then reflected forward from the anterior extremity of the body of the penis, overhanging the glans for a variable distance (when the penis is flaccid), so that a preputial sac is formed which ends blindly at the neck of the glans. The prepuce consequently has two surfaces, an outer one and an inner one directed toward the glans, these surfaces becoming continuous at the anterior extremity of the penis, forming the *preputial annulus* with a preputial orifice of variable size. Over the actual surface of the glans the integument is very thin and firmly adherent to the underlying tissue; it exhibits a smooth surface or (in the flaccid state) fine corrugations. The opposed surface of the prepuce likewise resembles a mucous membrane and is moist;

FIG. 491.—The corpora cavernosa of the penis.

The glans penis and the anterior part of the corpus cavernosum of the urethra have been drawn aside. * = Points which are in contact when the parts are in their natural position.

FIG. 492.—The male urethra with the corpora cavernosa of the penis, the bulbourethral glands and the prostate.

The corpus cavernosum of the urethra has been opened by a longitudinal incision in its mid-ventral line. ** = Sounds in the orifices of the bulbourethral glands.

FIG. 493.—The distal end of the penis with the prepuce.

The integument of the penis has been opened along the side and the prepuce separated from the glans.

FIGS. 494–497.—Transverse sections of the penis (through the middle of the body, at the base of the glans, through the middle of the glans and at its apex).

The corpus cavernosum of the urethra is yellow and that of the penis blue.

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it is attached to the sulcus upon the inferior surface of the glans by a slender longitudinal ligament, the *frenulum* of the prepuce (Figs. 493 and 497), but if the preputial orifice be not too small, the prepuce may be drawn back so as to uncover the glans.

In addition to the fixation of the crura penis to the rami of the pubes and ischia the penis is also attached by two special ligaments. The *fundiform ligament* (Fig. 245) consists chiefly of elastic tissue; it arises from the linea alba about five centimeters above the symphysis and runs to the dorsal surface of the fascia of the penis, radiating also to both sides of the organ and extending to its lower surface. The *suspensory ligament* arises from the anterior surface of the pubic symphysis as low down as the arcuate ligament, and consists of short tense fibrous fasciculi which run to the line of junction of the corpora cavernosa of the penis.

The arteries of the penis are derived chiefly from the internal pudic. The dorsal arteries run alongside the single vein in the groove between the corpora cavernosa; the profundæ penis course in the interior of the erectile bodies; the artery of the bulb supplies the bulb and the bulbourethral glands; and the urethral artery nourishes the urethra and its corpus cavernosum. The integument at the root of the penis also receives branches from the external pudic and posterior scrotal arteries.

The superficial veins form one or more subcutaneous vessels, which are situated chiefly upon the dorsum of the organ and empty into the great saphenous vein. The deep veins consist of the single vena dorsalis penis (subfascialis), which is composed principally of the veins of the glans and of the circumflex veins. It empties into the pudendal plexus. The deep veins situated within the corpora cavernosa form the main origins of the internal pudic veins.

The lymphatic vessels are numerous; they are subdivided into a superficial and a deep set and run to the inguinal glands.

The nerves are furnished partly by the ilio-inguinal and partly by the pudic, the latter supplying the organ by means of the perineal nerve and the dorsal nerve of the penis. A large number of sympathetic filaments from the pelvic plexuses pass to the penis, especially to its cavernous tissue.

THE FEMALE SEXUAL ORGANS.

THE FEMALE INTERNAL GENITALIA.

THE OVARY.

The *ovary* (Figs. 498 to 504 and 508) is the female genital gland. Like the testis, it is a paired organ, but it is much smaller; its shape is that of a markedly fattened, irregular ellipsoid. Its size varies not only according to age and sexual activity, but also exhibits marked individual

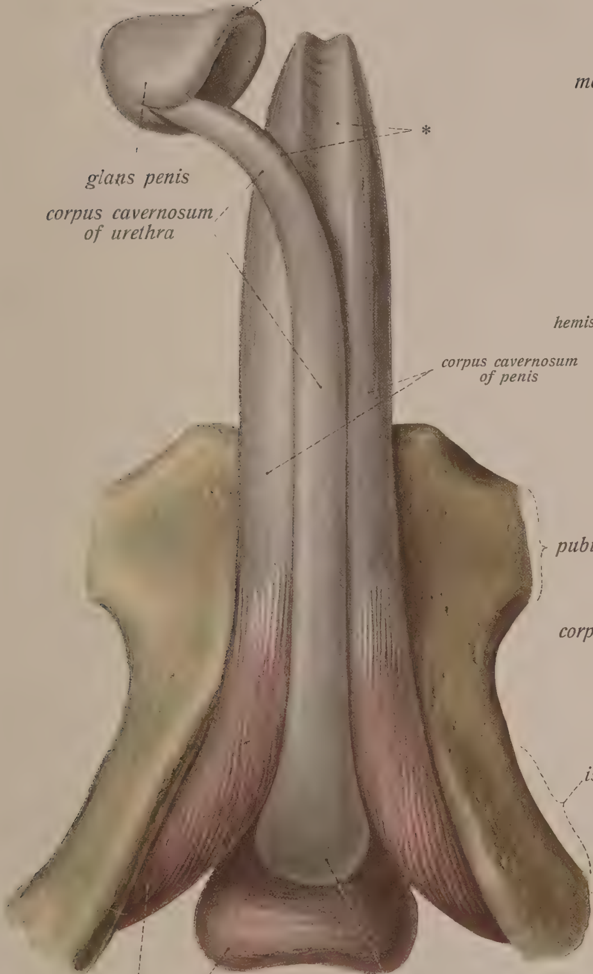


Fig. 491.

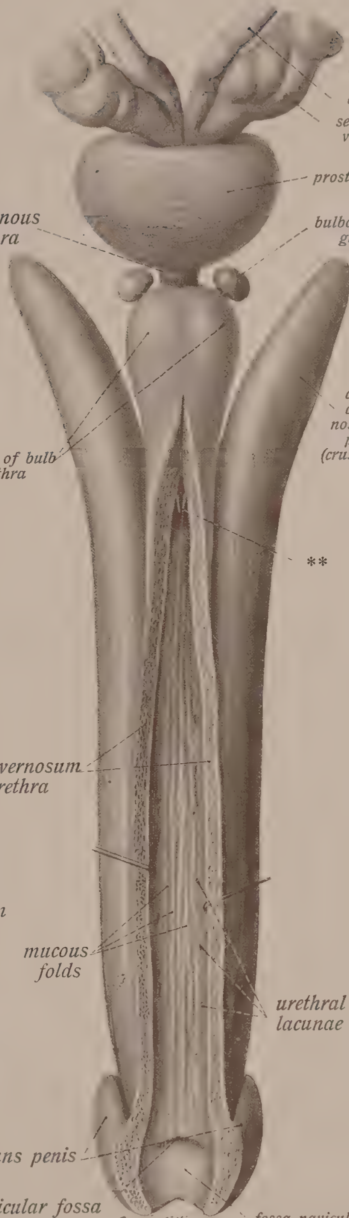


Fig. 492.

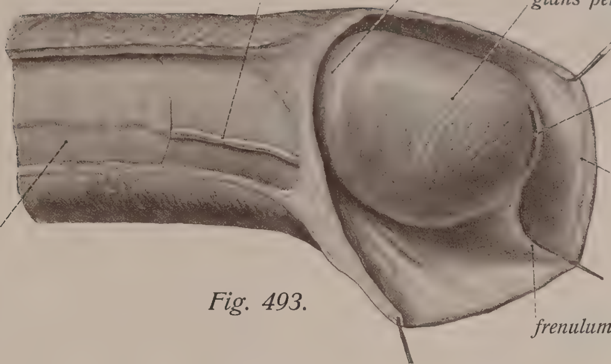


Fig. 493.

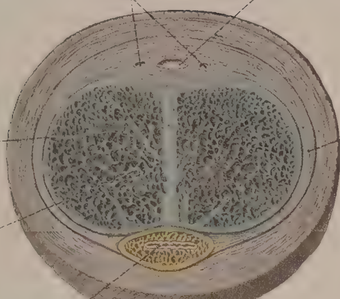


Fig. 494.

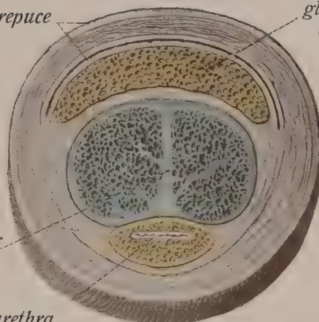


Fig. 495.

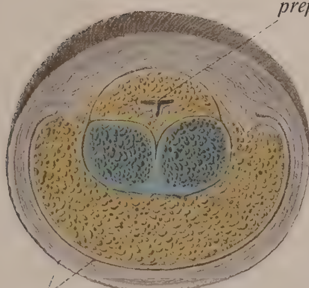


Fig. 496.

Fig. 497.

variations; its greatest length is 2.5 to 5.0 cm., its breadth 1.5 to 3.0 cm., and its thickness 0.6 to 1.5 cm. The surface directed toward and largely covered by the tuba uterina (Fallopian tube) is known as the internal surface, while that applied to the wall of the pelvis is known as the external surface, both surfaces being connected by rounded borders. The markedly convex and broader free border is directed backward and somewhat inward; the border attached to the mesovarium (see page 78) is known as the *mesovarian border*, and is straighter and is directed forward and outward. It presents the site of entrance of the vessels and nerves, the *hilus* of the ovary, which has the form of a groove of varying depth. One extremity of the ovary which is markedly rounded, looks upward toward the infundibulum of the tuba uterina; it is termed the *tubal extremity*, while the slightly pointed end, which looks downward and is attached to the uterus by the ovarian ligament, is known as the *uterine extremity*.

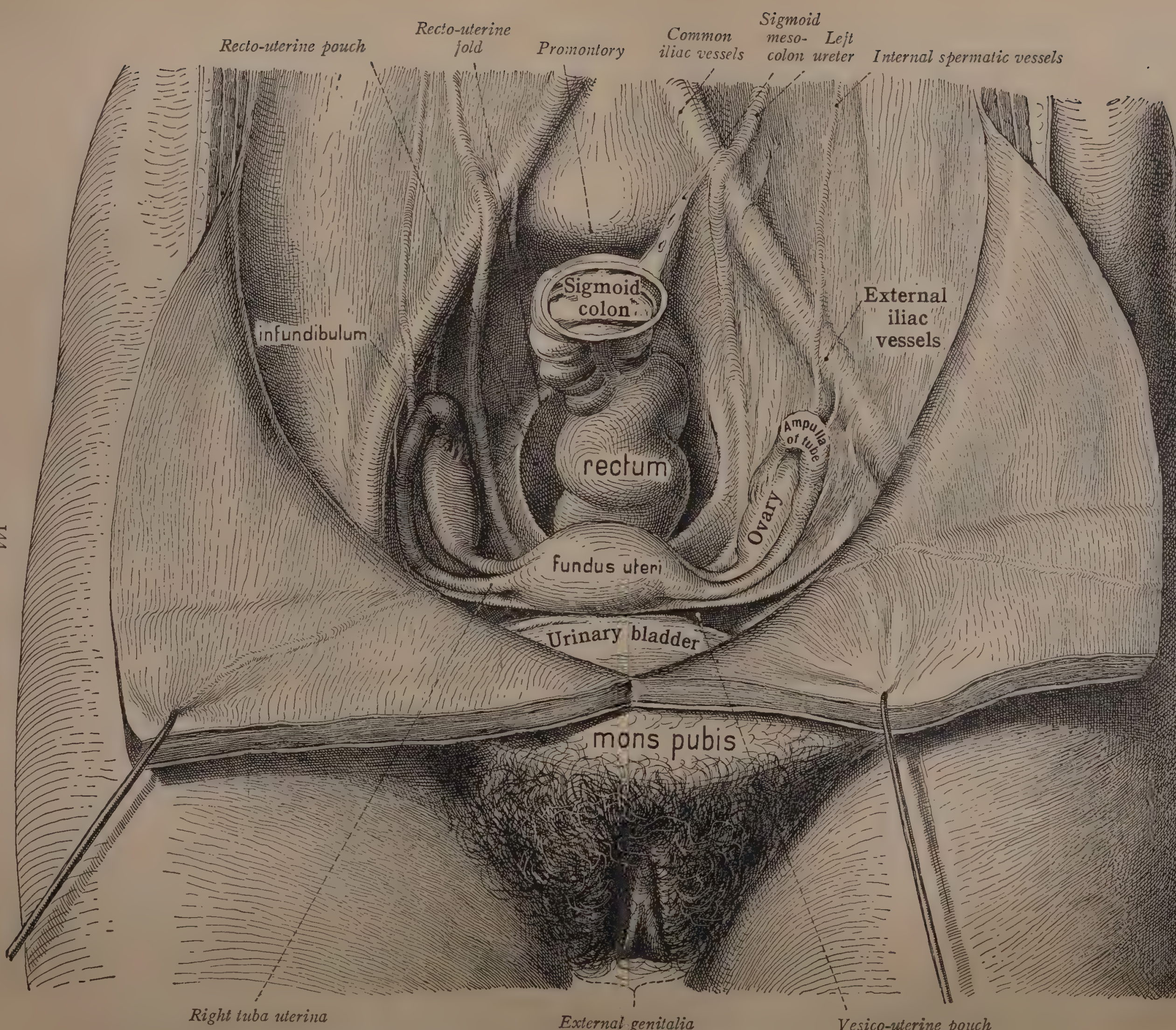
The surface of the ovary is either perfectly smooth, or else uneven and dimpled by scar-tissue according to the functional condition of the organ. It is quite hard and is whitish in the cadaver and reddish gray in the living subject.

The ovary is situated in the true pelvis in such a manner that its longitudinal diameter is almost vertical (Figs. 498 to 503). The uterine extremity is below and is directed somewhat forward and inward, while the tubal extremity is above and is directed backward and outward; the external surface looks outward and somewhat downward and the internal surface looks inward and also slightly upward. The tubal extremity lies immediately below the terminal (iliopectineal) line (in relation with the inner margin of the psoas major and the external iliac vessels) not far from the sacro-iliac synchondrosis, in a more or less well developed depression in the lateral pelvic wall, the *ovarian fossa*. This is bounded in front and above by the internal iliac artery and behind by the ureter and uterine artery, and laterally and therefore in the bottom of the fossa are the obturator vessels and nerve. The position of the ovary is dependent to a limited degree upon the position of the uterus. Not infrequently the two ovaries are unsymmetrically placed, one being higher than the other, particularly in oblique positions of the uterus.

The fundus of the uterus is connected with the uterine extremity of the ovary by a musculofibrous cord, the *ovarian ligament* (Figs. 500 to 504 and 508), which runs between the two layers of the broad ligament (see page 80). The tubal extremity is attached to the infundibulum of the Fallopian tube by the *fimbria ovarica* (the *infundibulo-ovarian ligament*), and also has attached to it the *suspensory ligament* of the ovary (the *infundibulopelvic ligament*), a musculofibrous cord which descends from the false pelvis and contains the ovarian vessels and nerves.

The ovary is attached to the posterior lamina of the broad ligament (see page 80), the epithelium of which becomes the germinal epithelium of the ovary, with which it is continuous at the hilus.

In the substance of the ovary a *cortical* and a *medullary* portion may be distinguished. The cortex is present over the entire surface except at the hilus, and attains its greatest thickness at the free border of the organ. It is characterized by the occurrence in it of vesicular structures, the Graafian follicles (*folliculi oöphori vesiculosi*) (Fig. 508), or of the products of their metamorphosis, the *corpora lutea*. The ovarian medulla is not sharply marked off from the cortical portion and contains chiefly the larger vessels of the organ.



FIGS. 498 and 499.—The female genitalia seen from above.

Fig. 498.

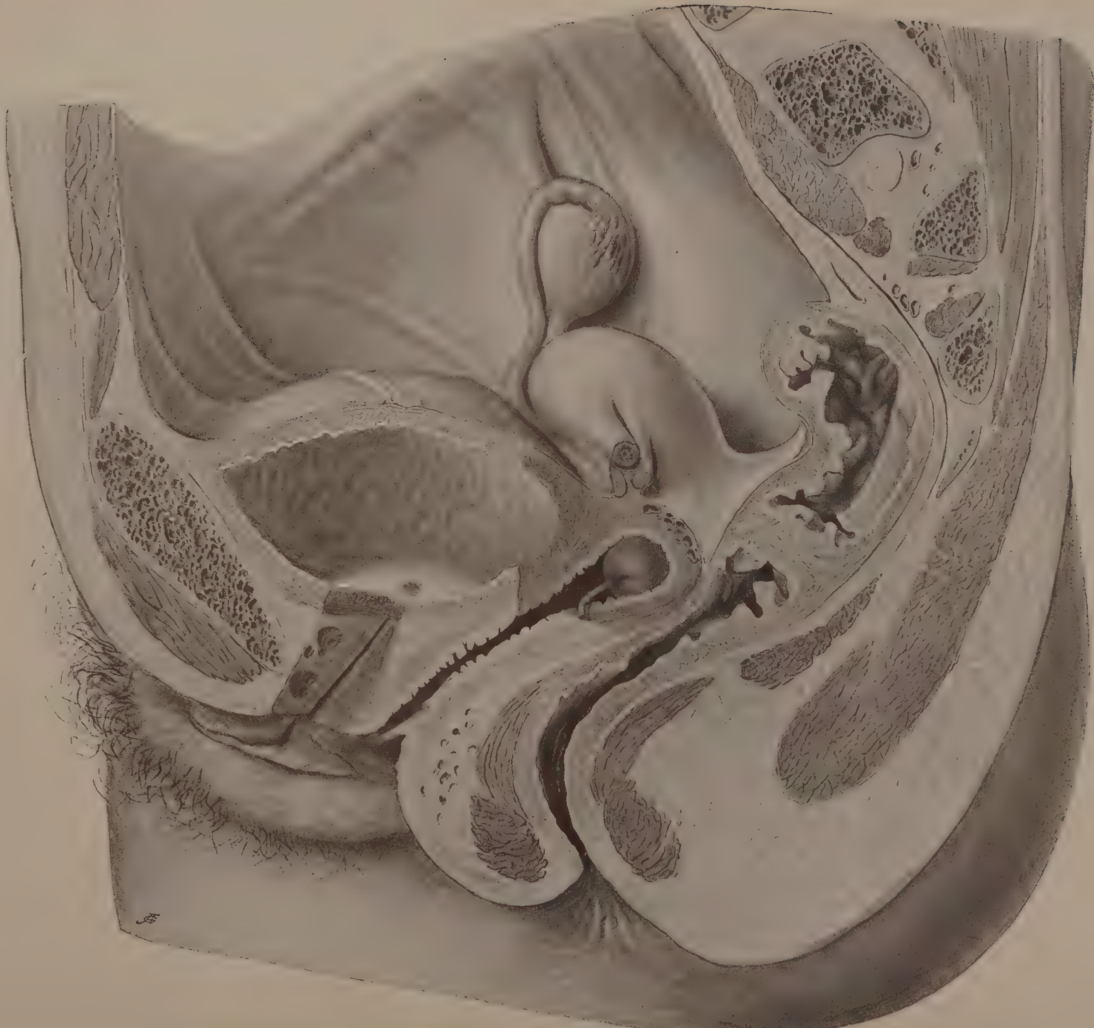
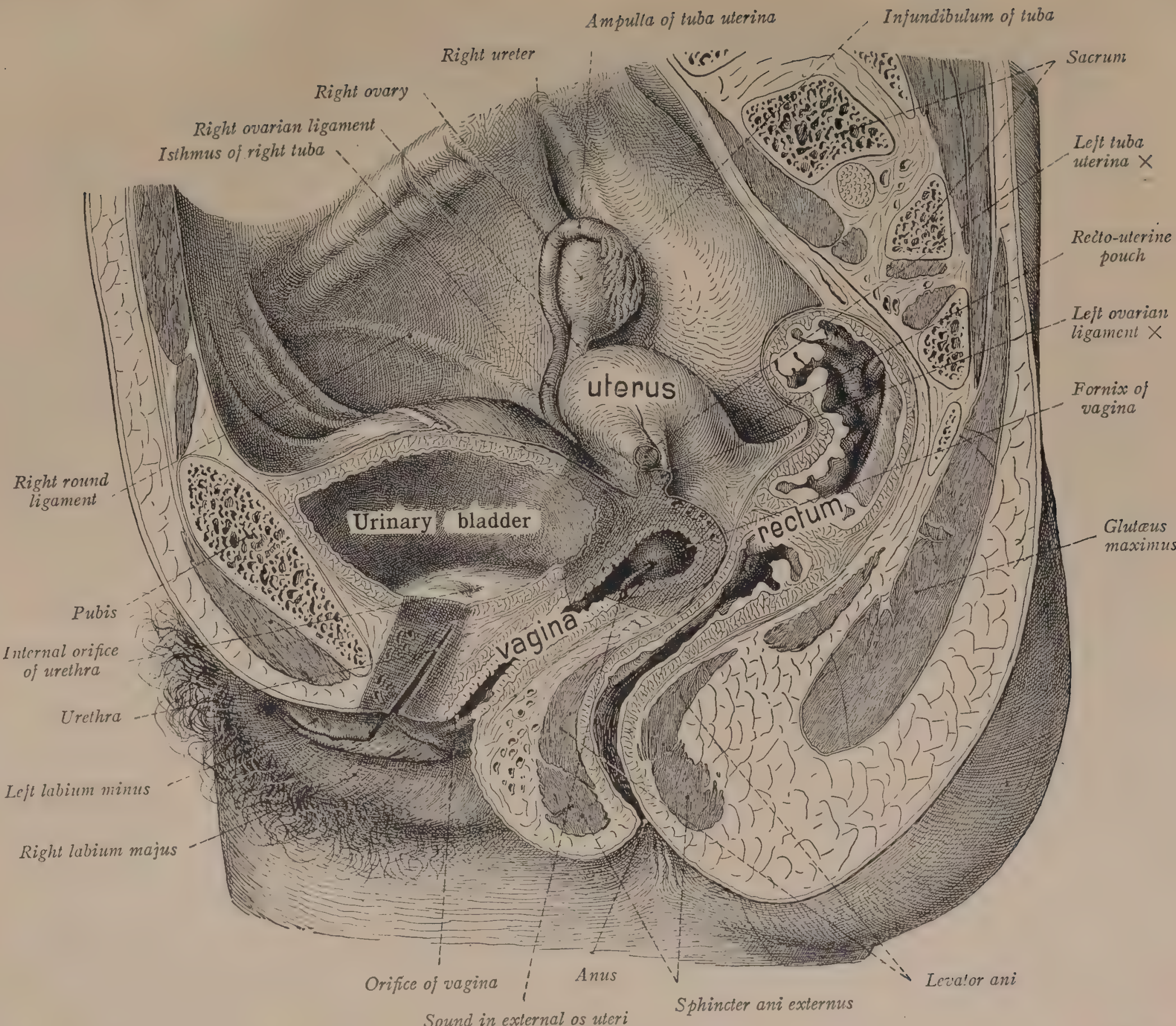
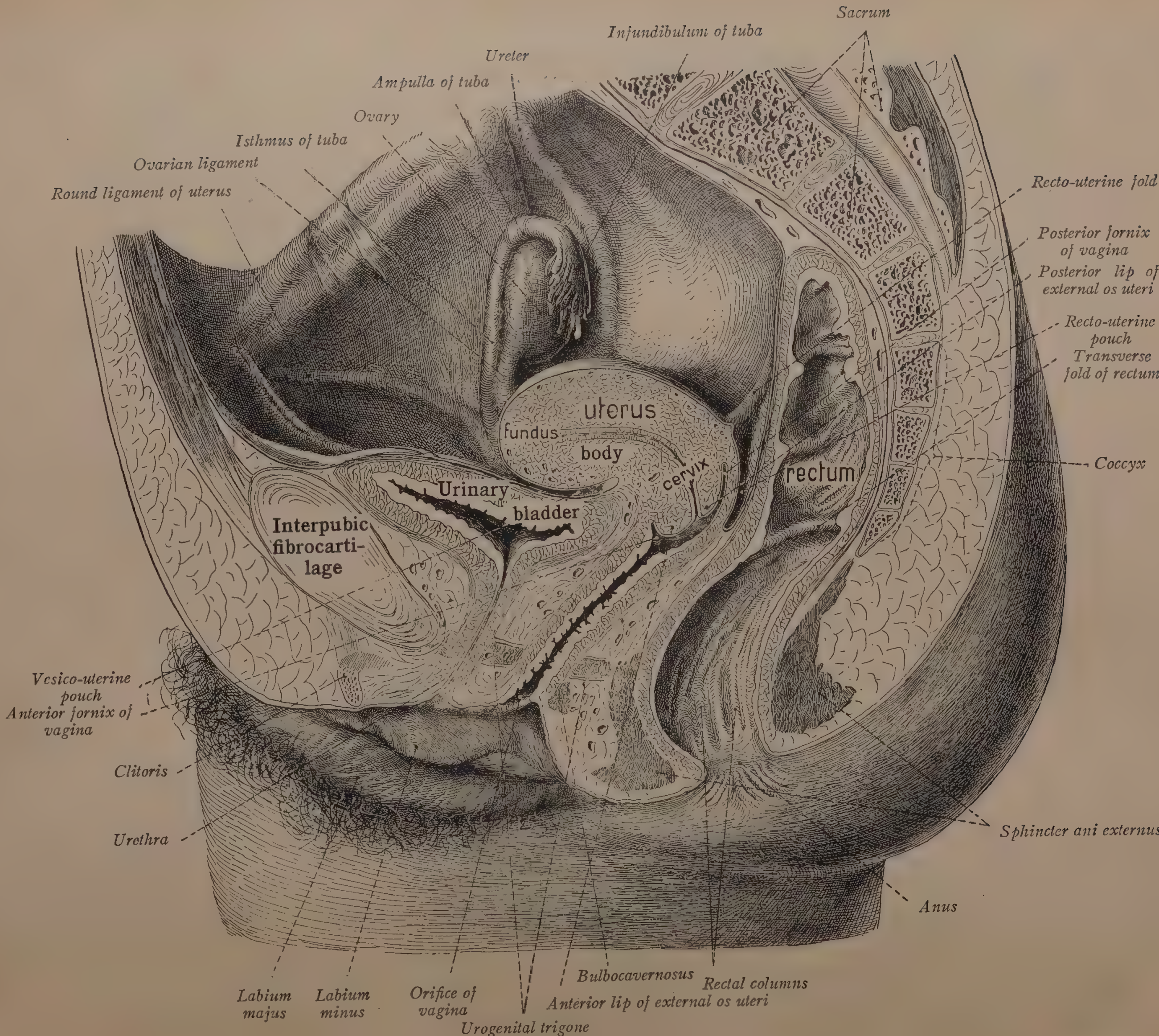


Fig. 501.



FIGS. 500 and 501.—The female genitalia seen from the left side. The pelvis and soft parts have been divided near the middle line. The left ovary and tuba uterina (Fallopian tube) have been removed and the urethra and vagina have been opened by an oblique section.



FIGS. 502 and 503.—A median longitudinal section of the female genitalia.

Fig. 502.

The ovary is supplied by two arteries which anastomose with each other, (1) the ovarian artery, derived from the aorta and passing to the organ in the suspensory ligament, and (2) the ovarian branch of the uterine artery.

The veins of the ovary correspond to the arteries. The ovarian veins form the pampiniform plexus and pass either to the inferior vena cava or to the renal vein, and the remaining branches empty into the uterine vein. At the hilus of the ovary the veins form marked plexuses between the two layers of the mesovarium (*bulbus ovarii*).

The lymphatic vessels pass to the lumbar glands, and the nerves of the ovary are sympathetic filaments which follow the course of the ovarian artery.

THE TUBA UTERINA (FALLOPIAN TUBE).

The tuba uterina (Fallopian tube) (Figs. 498 to 504 and 508) is a paired, cylindrical, muscular canal, 10 to 15 cm. long, which pursues a distinctly tortuous and markedly curved course in the upper margin of the broad ligament (see page 78). It serves to connect the ovary with the uterus, but is attached directly only to the latter structure. It commences at the ovary by a round opening leading directly into the abdominal cavity, the *abdominal orifice* (*ostium abdominale*), which is situated at the apex of the funnel-shaped *infundibulum.* This is a prolongation of the tubal wall, the inner surface of which is thrown into marked folds and which ends in a number of *fimbriæ* of varying length, so that the margin of the infundibulum seems to be frayed out. A particularly long fimbria runs to the tubal extremity of the ovary, usually forming a groove; it is termed the *fimbria ovarica* (*infundibulo-ovarian ligament*, see page 143), and its mucous folds are especially well developed. It is opposite the inner surface and the free border of the ovary.

Immediately succeeding the abdominal orifice of the tuba is the *ampulla*, which is wider than the portion lying nearer the uterus and is characterized by possessing flexures and strongly marked mucous folds. It commences with an acute flexure at the tubal extremity of the ovary, and then runs almost vertically downward along the lateral pelvic wall parallel to and just in front of the mesovarian border of the ovary.

The tuba then bends at a right angle and becomes continuous with the approximately straight *isthmus*, which pursues an almost horizontal course to the uterus, running inward, forward, and somewhat downward, and presenting a concavity which is directed upward. The narrowest portion, which runs partly within the uterine substance, is known as the *uterine portion;* its caliber is very small and it empties into the uterine cavity by a punctiform opening, the *uterine orifice* (*ostium uterinum*) of the tuba. The entire tube consequently consists of a short, practically horizontal uterine portion and of a longer vertical ovarian portion.

The relations of the tuba uterina are determined by those of the ovary, uterus, and broad ligament (see page 80).

The wall of the tube consists, in the first place, of the serous coat derived from the broad ligament, and the upper portion of the broad ligament, which furnishes this serous coat, is consequently also termed the *mesosalpinx* (Fig. 504) (see page 78). The terminal portion of the tube has no serous covering, since it is enclosed by the uterine wall, and the abdominal extremity or infundibulum projects beyond the broad ligament. Beneath the serous coat is a subserous fibrous coat, then a muscular coat consisting of a longitudinal and a circular layer, and finally a mucous coat. In the ampulla and isthmus of the tube this mucous coat is characterized by longitudinal folds, the *plicæ tubariæ*, which pass through the abdominal orifice to become continuous with the inner surfaces of the infundibulum and of the fimbriæ. In the ampulla, where they are known

FIG. 504.—The uterus with the broad ligaments, tubæ uterinæ, and ovaries, seen from behind.

FIGS. 505–507.—Transverse sections through the middle (Fig. 505) and lower end (Fig. 506) of the body and through the cervix (Fig. 507) of the uterus.

FIG. 508.—A frontal section of the uterus, the tuba uterina, the ovary, and the upper part of the vagina.

FIG. 509.—A sagittal section of the uterus and the upper part of the vagina.

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as the *plicæ ampullares* (Fig. 508), they are particularly long and are ramified so that the lumen of the ampulla becomes a complicated labyrinth composed of numerous capillary spaces. In the isthmus the folds are longitudinal and have no branches, and in the uterine portion of the tube they are either absent or almost entirely so.

The arteries for the tuba uterina are supplied by the ovarian and the uterine (the tubal branches). They pursue a curved course along the tube and anastomose with each other. The veins of the same name hold similar relations.

The lymphatic vessels of the tube probably pass to the lumbar lymphatic glands, and the nerves are derived partly from the sympathetic filaments for the ovary and partly from the uterovaginal plexus.

THE EPOÖPHORON AND OTHER APPENDAGES OF THE FEMALE INTERNAL GENITALIA.

The *epoöphoron* (*parovarium*) (Fig. 508) corresponds to the epididymis of the male and is the remains of the genital (proximal) portion of the Wolffian body (see page 125). It is situated in the outer portion of the mesosalpinx and consists of six to twelve approximately parallel tubules, 1 to 1.5 cm. in length, the *transverse ducts of the epoöphoron*, which pass into a longitudinal blind canal, the *longitudinal duct*, lying adjacent and parallel to the tuba uterina. The longitudinal canal is the remains of the anterior portion of the Wolffian duct (see page 125) and is not as constantly present as the transverse tubules. Although varying somewhat in the degree of its development, the epoöphoron almost always persists to adult life.

The *paroöphoron*, on the contrary, is distinctly demonstrable only up to the first year; it is the remains of the distal portion of the Wolffian body and corresponds to the paradidymis of the male. It is a small, flattened, rounded structure, and is situated in the mesosalpinx to the inner side of the epoöphoron.

Much more constant are the *appendices vesiculosæ* (*hydatids of Morgagni*) (Figs. 504 and 508), which are only rarely absent. They are attached either to the free margin of the mesosalpinx or to one of the fimbriæ, and are pedunculated vesicles, filled with fluid, about the size of a small pea. The pedicles frequently attain a considerable length.

THE UTERUS.

The *uterus* (Figs. 498 to 509) is a hollow, muscular, pear-shaped body, situated in the true pelvis. Its larger upper portion is termed the *body* or *corpus uteri*, and the smaller lower one the *neck* or *cervix uteri*, these two portions being separated by a constriction which is the narrowest part of the organ. The portion of the body which projects markedly above the entrances of the tubes is known as the *fundus*, and as the uterus is markedly flattened from before backward, an anterior and a posterior surface and two lateral margins may be recognized in it. The anterior surface is known as the *vesical surface*, the posterior more convex one as the *intestinal surface*, and the lateral margins as the *right* and the *left*. That portion of the cervix which projects into the

Fig. 504.

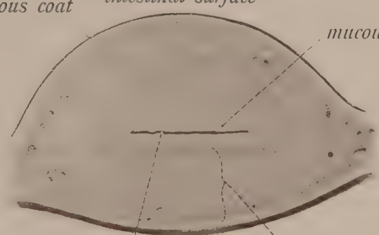


Fig. 505.

Fig. 506.

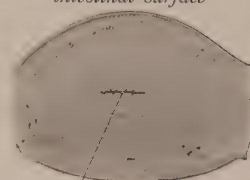


Fig. 507.

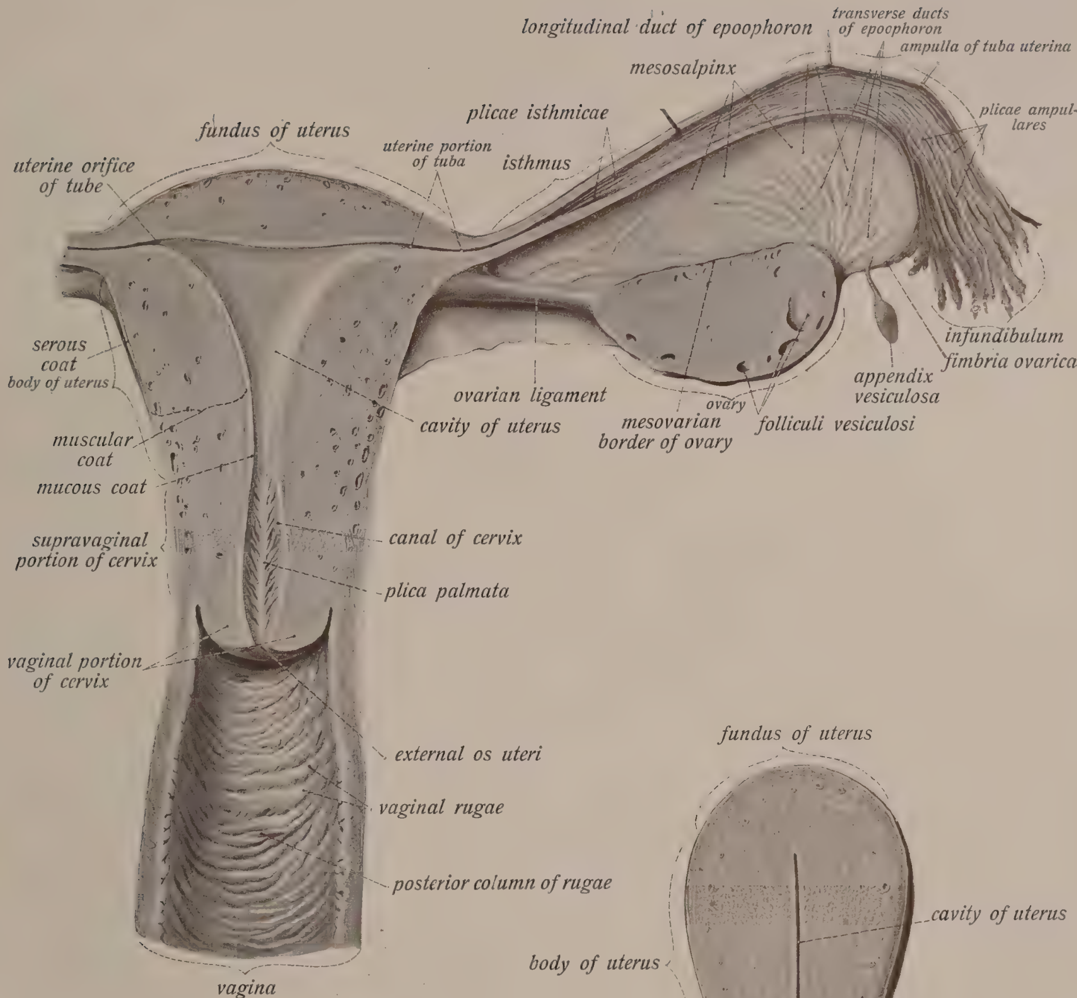


Fig. 508.

Fig. 509.

vagina is termed the *vaginal portion*, while that situated above the vagina is called the *supravaginal portion.*

The thick uterine wall surrounds a relatively small *cavity* (Figs. 508 and 509) in the body of the organ termed the *uterine cavity*, and in the cervix known as the *canal of the cervix*. The junction of the two portions is at the *internal os uteri*, the narrowest portion of the uterine lumen, corresponding to the constriction between the body and the cervix. The *uterine cavity* is merely a capillary space anteroposteriorly, but it has some extent in the transverse direction. It is irregularly triangular in shape, one angle being at the internal os and the other two at the internal orifices of the tubæ uterinæ, the line connecting the latter points being the shortest side of the triangle.

The *canal of the cervix* (Figs. 508 and 509) is approximately cylindrical, being slightly dilated at its center; it begins at the internal os uteri and opens into the vagina through the *external os uteri*. The external os of a nullipara as seen from the vagina is either a short transverse slit with smooth margins or a smooth round opening (Figs. 500, 501, and 510); in women who have borne children it is irregularly circular and exhibits a number of notches. Its thick margins are termed the *lips* (*labia*), the *anterior* being shorter and at a lower level than the *posterior* one. They are covered by the smooth vaginal mucous membrane and form the vaginal portion of the cervix.

On account of its intimate connection with the vagina the cervix of the uterus may be regarded as stationary, while the body is movable. The position of the internal os uteri is consequently on the line about which as about a transverse axis the body moves upon the cervix. The position of the uterus is essentially dependent upon the degree of distention of the bladder; when this viscus is empty, the uterine body is bent anteriorly upon the cervix (anteflexion); when it is full, the uterus straightens out so that the axes of the body and cervix more nearly correspond. In addition to this, the uterine axis is not placed vertically in the pelvic cavity, but passes obliquely from above downward and from before backward, so that the uterus seems "anteverted." These circumstances explain the varying levels of the lips of the external os (see also page 152). The uterus is not, as a rule, situated exactly in the median plane, but is inclined either to the right or to the left, so that the fundus is not directed exactly anterior but to one or the other side (sinistroversion, dextroversion).

The peritoneal covering of the uterus (Figs. 500 to 503) is derived from the broad ligaments (see page 77), which approach its lateral margins; the peritoneum invests its entire posterior surface, the posterior lip of the external os, and also the posterior aspect of the upper portion of the vagina. Upon the anterior surface, however, the peritoneal coat extends only to the level of the internal os, so that it is only the uterine body which is completely enveloped, the entire anterior surface of the cervix being uncovered by peritoneum. The peritoneal coat of the vesical surface passes over the fundus to become continuous with that of the intestinal surface without demarcation.

The uterus is situated in the central portion of the true pelvis and its vesical surface is always in contact with the urinary bladder. The cervix is rather firmly connected with the posterior vesical wall, but the body is separated from the bladder by the vesico-uterine fold of peritoneum. In the normal position of anteflexion this *vesico-uterine pouch* is a capillary space and never contains intestinal coils, so that the body of the uterus must follow the bladder in its varying degree of distention. The top of the uterine fundus extends upward to about the level of the transverse

vesical fold. The intestinal surface of the uterus is usually in relation with the intestinal coils situated in the recto-uterine pouch, but when the bladder and rectum are full it is in contact with the anterior rectal wall.

The portion of the uterus uncovered by peritoneum exhibits the following relations. At the junction of the supravaginal and vaginal portions of the cervix the vaginal mucous membrane is inserted, the musculature of the vagina being directly continuous with that of the uterus. The relations of the vaginal portion of the cervix within the vagina will be considered later on; those of the supravaginal portion are largely dependent upon the nature of the fixation of this portion of the uterus, the anterior surface of the cervix being in relation with the posterior vesical wall and with the ureter, the latter structure being about one centimeter distant. The main vessels pass to the lateral margins of the uterus.

The size and shape of the uterus vary according to its age and function. The infantile uterus is proportionately very small and does not grow much until puberty, and, compared with the cervix, the body is very small, broad and flat. The virgin uterus and that of a nullipara is still relatively small and the body and the cervix are of almost equal size, but after the birth of a child the body always remains larger and broader than it was before pregnancy, and the fundus is more markedly curved. During the later years of life, after the cessation of the function of the viscus, the cervix undergoes retrograde changes while the body remains large.

In nulliparæ the entire length of the uterus is 5 to 8 cm., about 4 cm. being taken up by the body. The greatest width of the body is 3.5 to 4 cm., and the greatest thickness 2.5 to 3 cm. In multiparæ the entire length is 6 to 9 cm.; the body is 4.5 cm. long, the cervix 2.5 to 3 cm. long. The greatest thickness of the body is 3 cm. The uterus of childhood is only 2 to 3 cm. long. During pregnancy the uterus exhibits an enormous increase in size.

The uterine wall is composed of three layers (Figs. 505 to 509), the serous coat (*perimetrium*), the muscular coat (*myometrium*), and the mucous coat (*endometrium*). The peritoneum which forms the serous coat is firmly adherent to the muscular coat without the intervention of any subserous tissue, and the musculature is extraordinarily thick, being the largest aggregation of non-striated muscle in the body. It is irregularly arranged and some of the fibers pass into the uterine ligaments of fixation without demarcation.

The uterine mucous membrane is also intimately adherent to the underlying musculature, a submucous layer being absent. In the uterine cavity it is smooth, but in the canal of the cervix it forms a system of folds (Fig. 508), the *plicæ palmatæ* upon the anterior and posterior walls, which are not obliterated by traction. Each system consists of a median longitudinal ridge with lateral transverse or oblique folds, the longitudinal fold upon the anterior wall being situated slightly toward the right, that of the posterior wall more to the left. The uterine mucous membrane contains the uterine glands; within the cervix they are known as the cervical glands. The surface of the vaginal portion of the cervix is invested by the vaginal mucous membrane.

The *parametrium* is the connective tissue along the sides of the cervix; it is rich in fat and contains the main arterial ramifications for the uterus. It is continued as a subserous connective tissue upon the posterior and lateral surfaces of the cervix where the peritoneum is not so firmly adherent as is the case upon the uterine body.

Since the uterus is situated centrally in relation with the neighboring portions of the female

genitalia, the latter are designated as the uterine adnexa. They consist chiefly of the broad ligaments and their contents (the ovaries and the tubes).

The uterus is held in position by a number of ligaments. The *broad ligament* (*ligamentum latum*) (Fig. 504) is a paired structure derived from the peritoneum, and more or less completely envelops the uterus and tubes. It is attached to the lateral margins of the uterus and consequently forms the *mesometrium*. The chief fixation of the uterus, however, is due to its intimate connection with the vagina and its consequent attachment to the pelvic floor. (Further details in reference to the broad ligament will be found in the description of the peritoneum upon page 77.)

In addition to the broad ligament, the uterus possesses other ligaments which are to be regarded as a continuation of its musculature. The most important of these is the *round ligament* (*ligamentum teres*) (Figs. 500 to 503), which is essentially a cylindrical or slightly flattened muscular cord, 12 to 15 cm. in length, which takes origin upon either side from the anterior surface of the uterus in the vicinity of the uterine extremities of the tubes, and runs at first almost horizontally and then forward and downward between the two layers of the broad ligament, covered mainly by the anterior one. It then passes forward and outward along the lateral pelvic wall, enveloped in a fold of peritoneum, like the vas deferens in the male, to the abdominal inguinal ring, and after traversing the inguinal canal, it passes out of the subcutaneous inguinal ring to gradually disappear in the fatty tissue of the labium majus. In the vicinity of the uterus the ligament is thickest and consists solely of connective tissue and non-striated muscle, but in its course through the inguinal canal it usually receives fasciculi of striated muscle fibers from the obliquus abdominis internus and the transversus (analogous to the cremaster in the male), which are continued upon it for a varying distance, frequently extending almost to the uterus, but never passing externally beyond the inguinal canal. The ligament extends about 2 cm. outside of the inguinal canal. Along with it run the external spermatic vessels of the female.

Similar continuations of the uterine musculature are the *mm. rectouterini* (Fig. 504), which run in peritoneal folds of the same name (see page 84), and connect the superficial musculature of the rectum with that of the uterus. The *uterosacral ligaments* are connective-tissue fasciculi which accompany the muscles in the similarly named peritoneal folds to the region of the second and third sacral vertebræ, where they fuse with the periosteum.

The arteries of the uterus are the uterine branches of the internal iliac. They run in the base of the broad ligaments, crossing the ureters 2 cm. from the margin of the uterus and pass inward to the parametrium and the lateral surface of the cervix, along which they run, becoming markedly tortuous (particularly after pregnancy) and rather closely applied to the uterine wall.

The veins form the uterine plexus, a portion of the utero-vaginal plexus. They at first accompany the arteries in pairs, but subsequently form single veins which empty with other venous trunks into the internal iliac vein.

The lymphatic vessels of the cervix empty into the inferior hypogastric glands, while those of the body run to the superior hypogastric and partly also to the lumbar glands.

The nerves are derived partly from the third and fourth sacral nerves and partly from the sympathetic pelvic plexus.

THE VAGINA.

The *vagina* (Figs. 500 to 503 and 508 to 510) is a rather capacious and markedly dilatable musculo-mucous canal, which extends from the uterus to the external genitalia. When collapsed it is markedly flattened from before backward, so that its lumen corresponds to the letter H, the

anterior and posterior walls being in contact, while small recesses occur on either side. The anterior wall is usually concave posteriorly, the posterior wall being correspondingly convex anteriorly.

The *anterior wall* is shorter than the posterior, and is about 6 to 7 cm. in length, the posterior wall being about 15 cm. longer. This is due to the fact that the axis of the cervix holds an oblique relation with the axis of the vagina, the vaginal portion of the cervix projecting into the vagina in such a manner that the lips of the external os are of unequal length (Fig. 509). The anterior wall is inserted into the base of the short anterior lip and the posterior wall into the longer posterior lip, so that the vaginal wall is firmly attached to the uterine wall and the vaginal mucous membrane is immediately reflected upon the lips of the external os (see page 149). In this manner there is formed a narrow circular space between the external os and the vaginal wall, the *fornix* of the vagina (Figs. 500 to 503 and 509), that portion of it lying in front of the external os uteri being termed the *anterior fornix*, that behind the external os the *posterior fornix*, and the intervening space the *lateral fornix*. On account of the great length of the posterior lip of the external os the posterior vaginal fornix is the deepest. The vagina is extremely dilatable, so that both its length and its breadth are subject to great variation; in virgins and nulliparæ it is of smaller caliber than in multiparæ, and its entrance or *introitus* is always the narrowest portion.

The anterior vaginal wall is in contact with the fundus of the bladder and with the urethra, and is rather firmly adherent to both of these structures. It is also intimately related with the ureter, which is situated between the upper portion of the anterior vaginal wall and the bladder. About 1 to 1.5 cm. of the upper portion of the posterior vaginal wall (the posterior fornix and the contiguous portion of the lateral one) are invested by the peritoneum of the recto-uterine pouch (see page 77), but the remaining portions have no peritoneal covering whatever. The lower portion of the posterior vaginal wall is in contact with the rectum, but the upper portion is separated from this structure by the recto-uterine pouch.* The lateral walls of the vagina are surrounded by a venous plexus and, like the entire vaginal circumference, are in contact with the muscles and fascia of the pelvic floor, especially with the urogenital trigone and the levatores ani (see page 156). The lower portion of the vagina is surrounded by the sphincter-like fibers of the mm. bulbocavernosi (Figs. 500 to 503) (see page 160).

With the exception of the posterior vaginal fornix, which possesses a serous coat, the vaginal wall consists of a fibrous, a muscular, and a mucous coat. The fibrous coat is adherent to the neighboring viscera (the bladder, the urethra, and the rectum), and the muscular coat is well developed, though weaker than that of the uterus, with which it is directly continuous at the attachment of the vagina to the cervix. The mucous membrane contains no glands, and a submucous layer is wanting, as in the uterus. Upon both the anterior and the posterior vaginal walls the mucous membrane forms curved transverse folds, the *vaginal rugæ* (Figs. 508 and 510), which together with a longitudinal elevation on each wall form the *columnæ rugarum* (*anterior* and *posterior*). The lower portion of the columna rugarum anterior is especially prominent and is produced by the lower portion of the urethra, which projects into the vagina as the *urethral carina* (Fig. 510) and is even visible in the vaginal vestibule. The folds of the vaginal mucous mem-

* This pouch occasionally contains coils of small intestine, which then hold a relation to the vagina.

brane are rather firm and sharply defined in virgins, but they gradually disappear after repeated births; the mucous membrane covering the vaginal portion of the cervix possesses no folds whatever.

At the vaginal entrance of virgins a fold proceeds from the posterior vaginal wall which is known as the *hymen* (*hymen feminus*) (Fig. 512). When tense, it is usually sickle-shaped, since it generally disappears upon the lateral wall of the vaginal entrance, but it is not infrequently continued around the anterior circumference of the vaginal entrance, so that it is circular with an eccentric opening. The margin of the sickle-shaped hymen is usually smooth, while that of the circular one is frequently notched (*hymen fimbriatus*), and the opening in the fimbriate hymen is rarely central. When the thighs are adducted the opening of the (sickle-shaped) hymen appears like a median fissure, the lateral portions of the hymen being thrown into folds. The hymen is usually torn during the first coition, but its remains persist for a long time, and, particularly after the birth of a child, they form short irregular lobes or warts, the *carunculæ hymenales* (Fig. 510).

The upper portion of the vagina is nourished by the uterine artery, which runs in the immediate proximity of this portion of the lateral vaginal wall on its way to reach the uterine cervix. The middle portion receives the inferior vesical artery, and the lower portion is supplied by the middle hemorrhoidal and the internal pudic arteries.

The veins, like those of almost all the pelvic viscera, form a plexus upon the vaginal wall and empty into the internal iliac vein.

The lymphatics of the lower portion of the vagina and of the region of the hymen pass with those of the labia minora to the inguinal glands and partly also to lymphatic glands situated within the pelvis. The lymphatics of the middle portion pass independently to the hypogastric and iliac glands, while those of the upper portion empty into the same glands along with the lymphatics of the cervix.

The nerves for the lower portion of the vagina are derived from the pudic, those for the upper portion from the nerves for the uterus (see page 151).

The Female External Genitalia.

THE VULVA (PUDENDUM MULIEBRE).

The *vulva* (Figs. 510 to 512) is essentially the slightly transformed urogenital sinus (see page 127). It consists of a median fissure, the *rima pudendi*, and its boundaries, the *labia majora*, these latter being thick cutaneous folds, rich in fat, which vary in their development in different individuals and are connected anteriorly and posteriorly by less distinct folds, the *anterior* and *posterior commissures* (Fig. 512).* They are situated below the mons pubis, a region which is prominent on account of the development of its fatty tissue and is covered with hair. Posteriorly they extend to the perineum, and laterally they are separated from the inguinal regions by cutaneous sulci. The external surfaces of the labia majora exhibit the usual characteristics of the integument; they possess a large number of sebaceous glands and a sparing number of large hairs. Their inner surfaces resemble mucous membrane and rarely possess hairs, although these structures may be present at the margins of the labia. The labia majora are in contact when the thighs are adducted, but they gape in multiparæ. The round ligaments of the uterus terminate in their fatty tissue (see page 151). They are 7 to 8 cm. in length, and their greatest breadth is 2 to 3 cm.

* The posterior commissure is rarely distinctly developed, in contrast with the anterior one, which is almost always demonstrable.

FIG. 510.—Vagina and external genitalia of a woman who had borne children.

The vagina has been opened from its lateral wall.

FIG. 511.—Erectile structures of the female urogenital sinus and the greater vestibular glands.

The bulbocavernosus has been largely removed; the labia minora have been retained up to the prepuce of the clitoris.

FIG. 512.—The external genitalia of a virgin of eighteen years.

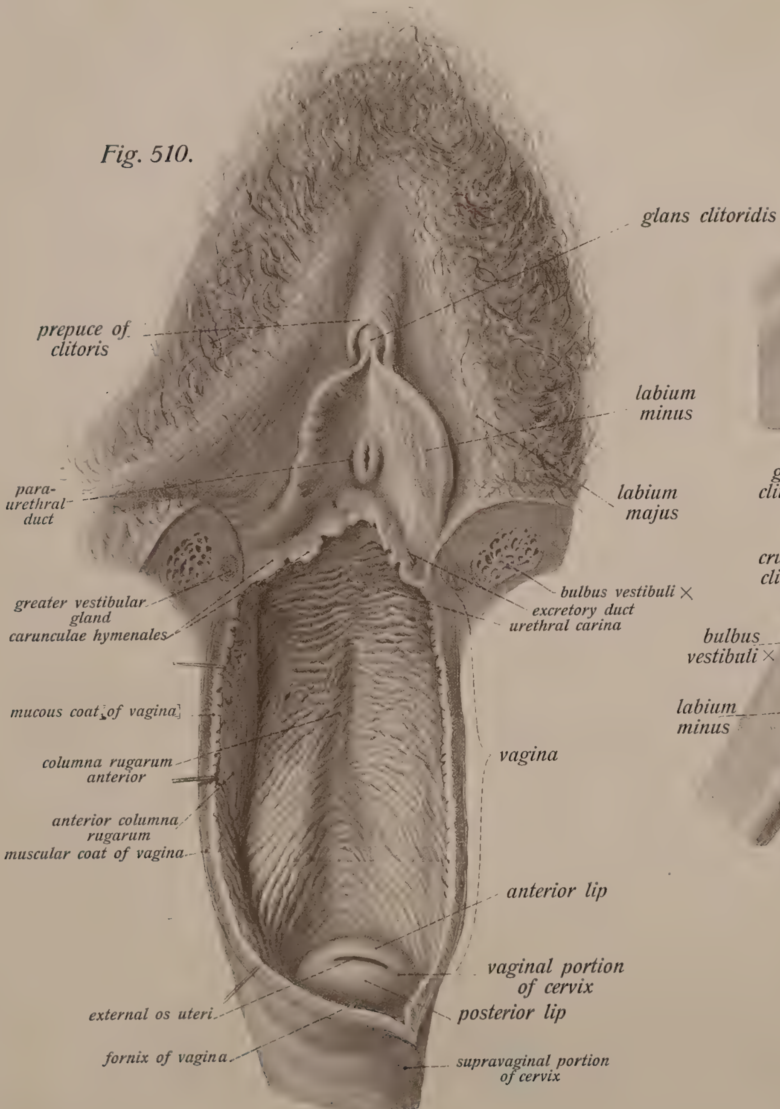
The *labia minora* (Figs. 500 to 503, 510, and 512) are similar cutaneous folds, but they are usually much shorter, narrower, and lower than the labia majora. They are situated in the sagittal plane and are approximately parallel to the inner surfaces of the labia majora. They contain a particularly large number of sebaceous glands and veins, are entirely destitute of hairs, even the lanugo hairs being wanting, and their connective tissue contains no fat. Their outer surfaces are directly continuous with the inner surfaces of the labia majora, and their borders are subject to great individual variation, exhibiting lobules or notches, and the two surfaces are frequently wrinkled and uneven. The labia minora as a whole also exhibit many individual and racial peculiarities. When markedly developed they may project beyond the labia majora and protrude from the rima pudendi,* or the two labia minora may be of unequal size.

As a rule, they are highest near their anterior extremities, and they gradually become lower as they pass backward and disappear in a small transverse fold, the *frenulum* of the labia (Fig. 512), situated in front of the posterior commissure. This structure is generally absent in multiparæ, since it is usually torn during birth. In virgins and women who have not borne children there is also a shallow depression between the frenulum and the perineum, the *fossa navicularis* (*fossa vestibuli vaginæ*) (Fig. 512), which, in the virgin, is limited anteriorly by the hymen. As the labia minora pass anteriorly they suddenly become narrower, and do not reach to the anterior commissure, but extend only to the clitoris, the glans of which they enclose, to form the *prepuce* and *frenulum* of the clitoris. The labia minora are 25 to 35 mm. long and 3 to 5 mm. thick; their greatest height varies between 8 and 15 mm.

The area bounded laterally by the labia minora is the female urogenital sinus and is termed the *vestibule of the vagina*. In its most anterior and superior portion is situated the *clitoris*, a structure which in shape and position corresponds to the penis, but is in reality comparable only to the corpora cavernosa penis. It differs from the penis in that it is much smaller and is not perforated, but merely grooved upon its under surface by the urethra. The *crura of the clitoris* arise from the junction of the pubis with the ischium and are composed of the *body* of the clitoris and of the *glans clitoridis*. The clitoris is composed of two elongated erectile bodies, the *corpora cavernosa of the clitoris*, whose general structure corresponds to that of the corpora cavernosa penis, and, like the latter structures, they are similarly covered by the mm. ischiocavernosi (see page 160). The body of the clitoris is flattened from side to side, and the two corpora cavernosa are firmly adherent to each other, so that they are separated only by an incomplete septum. Like the corpora cavernosa of the penis, they are surrounded by a fascia, the *fascia of the clitoris*, and the clitoris also possesses a *suspensory ligament*. At the junction of the crura with the body of the clitoris at the lower margin of the pubic symphysis, the clitoris bends at an acute angle (almost a right angle), the *angle of*

* The so-called Hottentot apron.

Fig. 510.



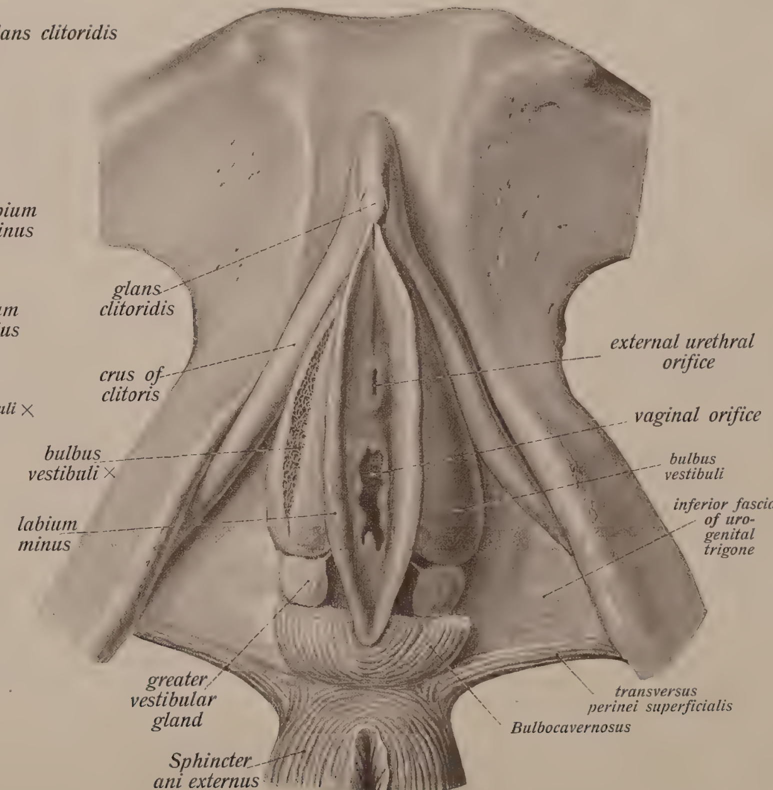


Fig. 511.

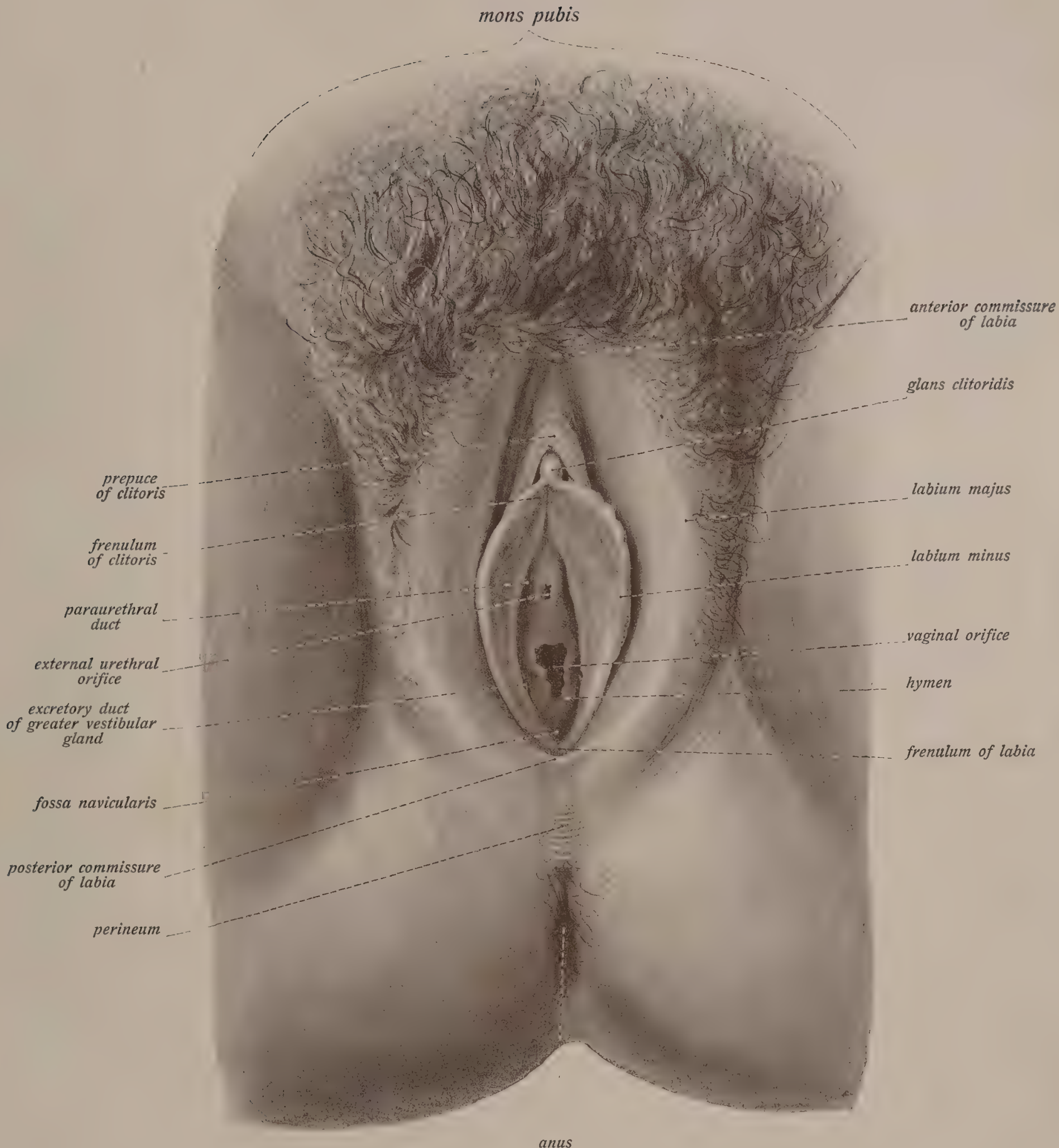

mons pubis
anterior commissure of labia
glans clitoridis
prepuce of clitoris
labium majus
frenulum of clitoris
labium minus
paraurethral duct
vaginal orifice
external urethral orifice
hymen
excretory duct of greater vestibular gland
frenulum of labia
fossa navicularis
posterior commissure of labia
perineum
anus

Fig. 512.

the clitoris, so that its body holds almost a vertical position beneath the labia majora in the region of the anterior commissure (Figs. 502, 503, and 510). In contrast with the corresponding curve in the flaccid penis in the male, this angle of the clitoris is unchanged by the erection of the organ.

The slightly thickened rounded or pointed anterior extremity of the clitoris, the *glans* (Figs. 510 to 512), protrudes into the anterior extremity of the genital fissure (Fig. 512), and is surrounded by the integument which lines the entire vestibule of the vagina. The labia minora join in front of the glans to form a long *prepuce*, which usually projects beyond the end of the glans, while behind the clitoris they form a small fold, the *frenulum*, which gradually disappears upon the lower surface of the glans.

Immediately behind and below the frenulum of the clitoris the vestibule of the vagina presents the *external orifice of the urethra* (Figs. 510 to 512), which is usually situated upon a slight elevation, the *urethral papilla*. It is a small orifice irregularly bounded by lobulated or serrated margins which are usually situated in the sagittal plane, and behind and below it is situated the entrance of the vagina (see page 152).

The integument which lines the vestibule of the vagina somewhat resembles a mucous membrane. It contains small mucous glands, the *lesser vestibular glands*, some of which open into small pit-like depressions. A well-developed duct is rather constantly found to either side of the urethral orifice; these are known as the *paraurethral ducts* (Fig. 512) and belong to glands situated within the urethral wall.

The vestibule also contains the orifices of the excretory ducts of the *larger vestibular glands* (*glands of Bartholin*), these being situated at the junction of the posterior and middle thirds of the lateral circumference of the vaginal orifice, and at a point where the skin of the vestibule passes into the vaginal mucous membrane (Fig. 512). They are anterior to the hymen when this structure is present. The gland itself corresponds in structure to the gland of Cowper in the male; it is frequently somewhat larger, however, and is elongated and flattened. It is situated at the posterior extremity of the bulbus vestibuli at the lateral circumference of the vaginal entrance, and is covered by the integument of the vestibule (from which it is separated by a distance of 1 to 1.5 cm.) and by the m. bulbocavernosus.

The *bulbus vestibuli* (Figs. 510 and 511) is an erectile body, homologous with the bulb of the corpus cavernosum of the urethra in the male, and consists of two almost entirely separated halves, flattened from side to side, thickened at their posterior extremities and situated on either side of the vaginal orifice. Anteriorly they become narrower and are connected by a venous plexus situated between the urethral and the vaginal orifices, so that the two bulbs form a horseshoe which is open posteriorly and inferiorly, *i. e.*, toward the vaginal orifice. They resemble a cavernous plexus rather than erectile bodies, and do not possess a true tunica albuginea.

The superior and anterior border of the bulbus vestibuli is in contact with the trigonum urogenitale; the inferior border is situated in the base of the labia majora.

The greater portion of the blood-supply of the female external genitalia is derived from the internal pudic artery, a smaller portion coming from the femoral artery. The anterior halves of the labia majora are supplied by the anterior labial branches of the external pudic (from the femoral), while the posterior halves receive the posterior labial branches of the internal pudic. The labia minora are also nourished by the posterior labial arteries, the clitoris receives the dorsal artery of the clitoris from the internal pudic, while the bulbus vestibuli and the vestibular glands receive their branches from the artery of the bulbus vestibuli, which arises from the internal pudic.

The veins of the external genitalia nearly all empty into the internal pudic vein, although some of them pass to the internal saphenous vein and to the dorsal vein of the clitoris. They also form a plexus in the external genitalia, which is connected with the numerous venous plexuses situated within the pelvis.

The lymphatics pass to the superficial inguinal glands, and the nerves are the anterior labial branches of the external spermatic and the posterior labial branches of the pudic for the labia majora, the latter nerves also supplying the labia minora, and the dorsal nerve of the clitoris for this structure and its prepuce.

The Perineum.

The *perineum* (Fig. 512) is that portion of the perineal region situated between the vaginal and anal orifices in the female and between the scrotum and the anus in the male. The male perineum is longer and narrower than that of the female, the latter owing its greater breadth to the greater width of the pelvic outlet. In both sexes the perineum presents a median raphe; especially well marked in the male, where it is immediately continuous with the raphe of the scrotum. The skin of the perineum is rich in fat, and beneath the layer of fatty tissue is found the perineal musculature which forms the pelvic floor.

THE PERINEAL MUSCLES.

The perineal muscles (Figs. 482, 483, 500 to 503, and 513 to 516) include not only the actual muscles of the perineum, but also the striated musculature of the anus and its vicinity. They are striated voluntary muscles, some of which are the remains of retrograded skeletal muscles (caudal muscles).

The **levator ani** (Figs. 500, 501, 513, 515, and 516) is a paired smooth muscle, the origin of which holds intimate relations with a tendinous strip embedded in the obturator fascia overlying the obturator internus, the *tendinous arch* of the levator ani (*white line*) (Fig. 513). This is a condensed portion of the obturator fascia, which runs from the region of the obturator canal to the spine of the ischium. The levator ani arises from this strip, from the inner surface of the superior ramus of the pubis, and from the pubis parallel to the symphysis, and as the result of the marked bend of the pubic bone in the region of the obturator foramen, the line of origin presents a decided curve. The fibers coming from the pubis form a compact layer, while those arising from the tendinous arch form slenderer fasciculi, frequently separated at their origins by small interspaces. The posterior portion of the origin of the muscle bridges over the great sacrosciatic foramen and its contents, including the piriformis.

The levator ani is composed of two portions which are designated as the *m. pubococcygeus* and the *m. iliococcygeus*. The *pubococcygeus* (Figs. 513, 515, and 516) includes the fibers coming from the pubis, and in the male it runs close beside the prostate to the rectum. It passes through a small portion of the fibers of the sphincter ani externus to reach the posterior circumference of the anus, where the greater portion of the fibers intermingle, behind the rectum, with the corresponding muscle of the opposite side and with the longitudinal fasciculi of the rectal musculature. In the female (Fig. 516) the muscle fibers run downward on either side of the urethra and vagina, are connected with the longitudinal musculature of these structures, and hold the same relation to the rectum as they do in the male. The larger portion of the pubococcygeus does not insert in the

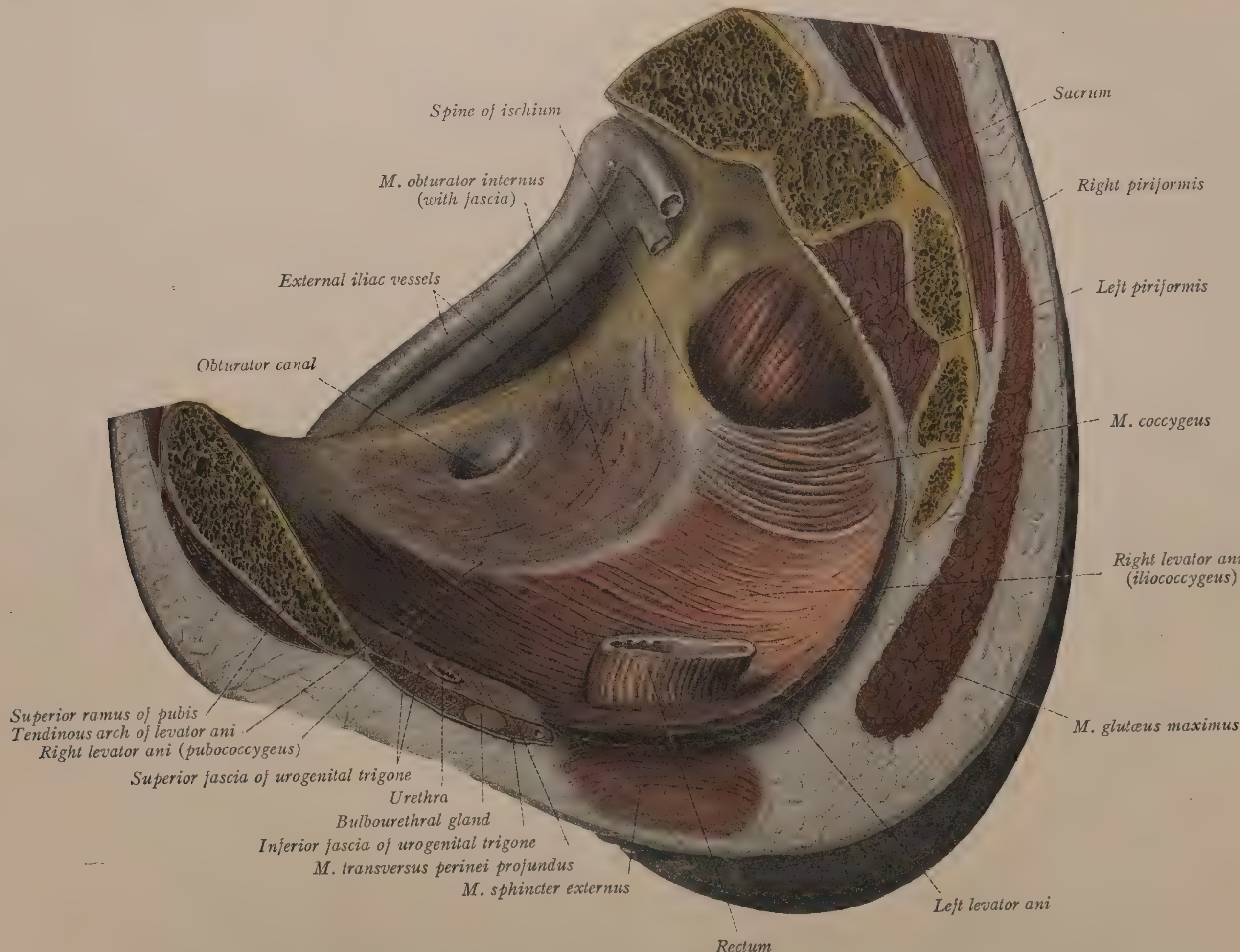


FIG. 513.—The perineal musculature of the male seen from the left side after removal of the bladder and rectum.

FIG. 515.—Superficial muscles of the male perineum.
FIG. 516.—Superficial muscles of the female perineum.

On the left side the bulbocavernosus is entirely and on the right side partly exposed. The ischiocavernosus is exposed only on the left side.

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rectum but passes by this structure to end in an aponeurosis which is attached to the anterior surface of the sacrococcygeal ligament.

The *iliococcygeus** (Figs. 513, 515, and 516) is the larger portion of the levator, and arises from the tendinous arch. A portion of it inserts into the lateral margin of the coccyx, while the remainder joins with its fellow of the opposite side in the *anococcygeal ligament* (Fig. 515), a fibromuscular cord which passes from the tip of the coccyx to the posterior circumference of the anus.

The nerve for the levator ani is derived from the sacral plexus and enters the pelvic surface of the muscle. The levator ani elevates the pelvic floor and also acts upon the rectum.

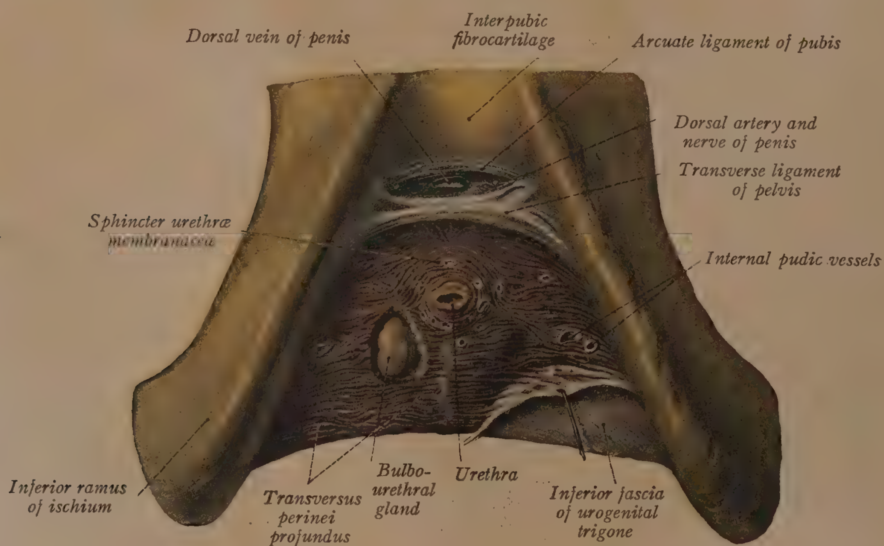
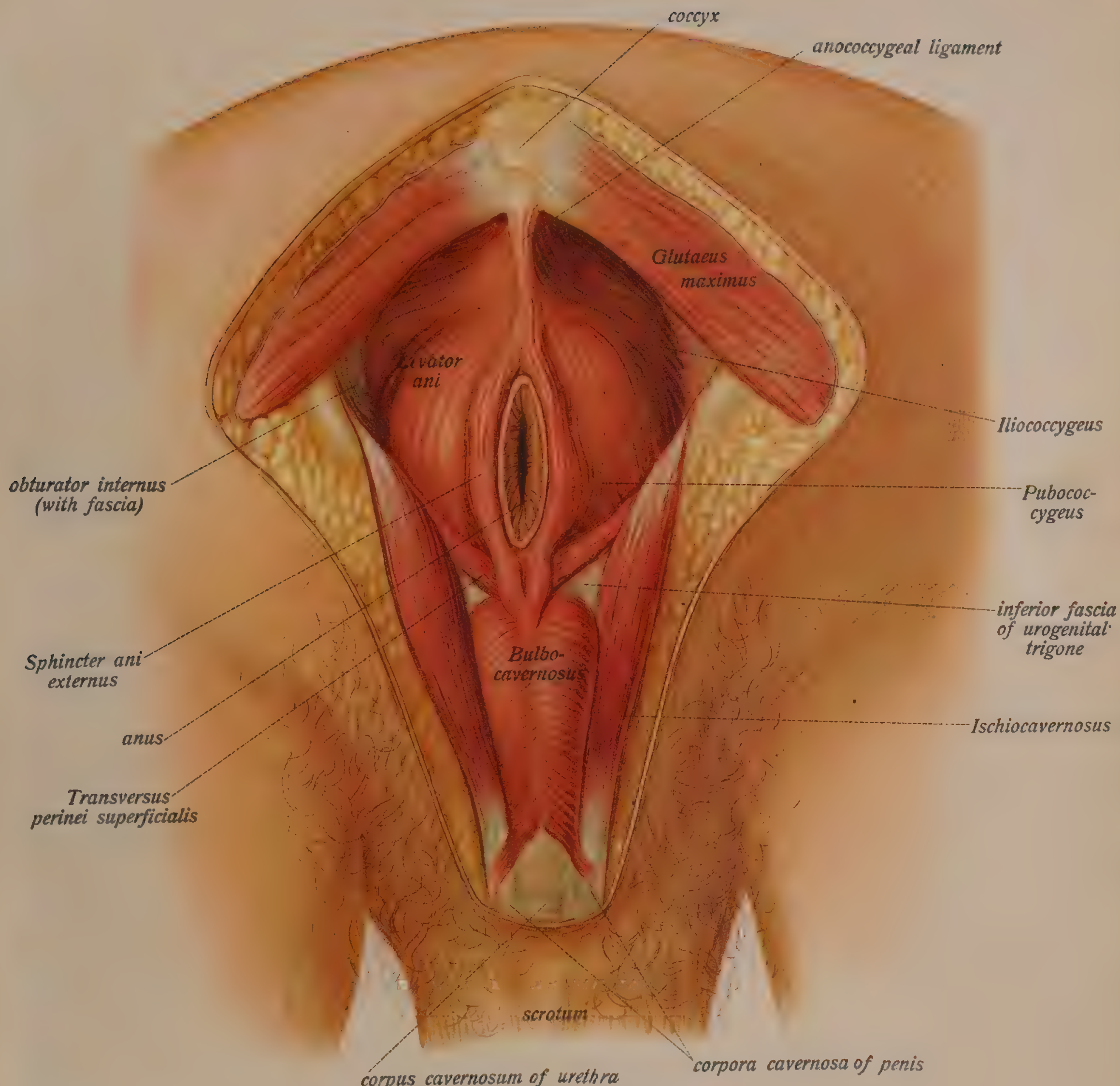


FIG. 514.—The urogenital trigone of the male seen from its perineal surface. On the right side the inferior fascia has been partly retained to show its connections with the muscle; on the left side it has been entirely removed and the muscle cut away so as to expose the bulbourethral gland.

The **coccygeus** (Figs. 299, 300, and 513) is immediately behind the posterior portion of the levator ani and seems to be a direct continuation of this muscle. It lies upon the pelvic surface of the sacrospinous (lesser sacrosciatic) ligament as a musculotendinous lamina. It is intimately connected with the levator ani, and the course of its fibers accurately corresponds to that of the fasciculi of the sacrospinous ligament.

* The name "iliococcygeus" is justified by the fact that in most mammals it arises directly from the ilium and not from the tendinous arch.



coccyx
anococcygeal ligament
Glutaeus maximus
Levator ani
Iliococcygeus
obturator internus (with fascia)
Pubococ-cygeus
inferior fascia of urogenital trigone
Sphincter ani externus
Bulbo-cavernosus
anus
Ischiocavernosus
Transversus perinei superficialis
scrotum
corpus cavernosum of urethra
corpora cavernosa of penis

Fig. 515.

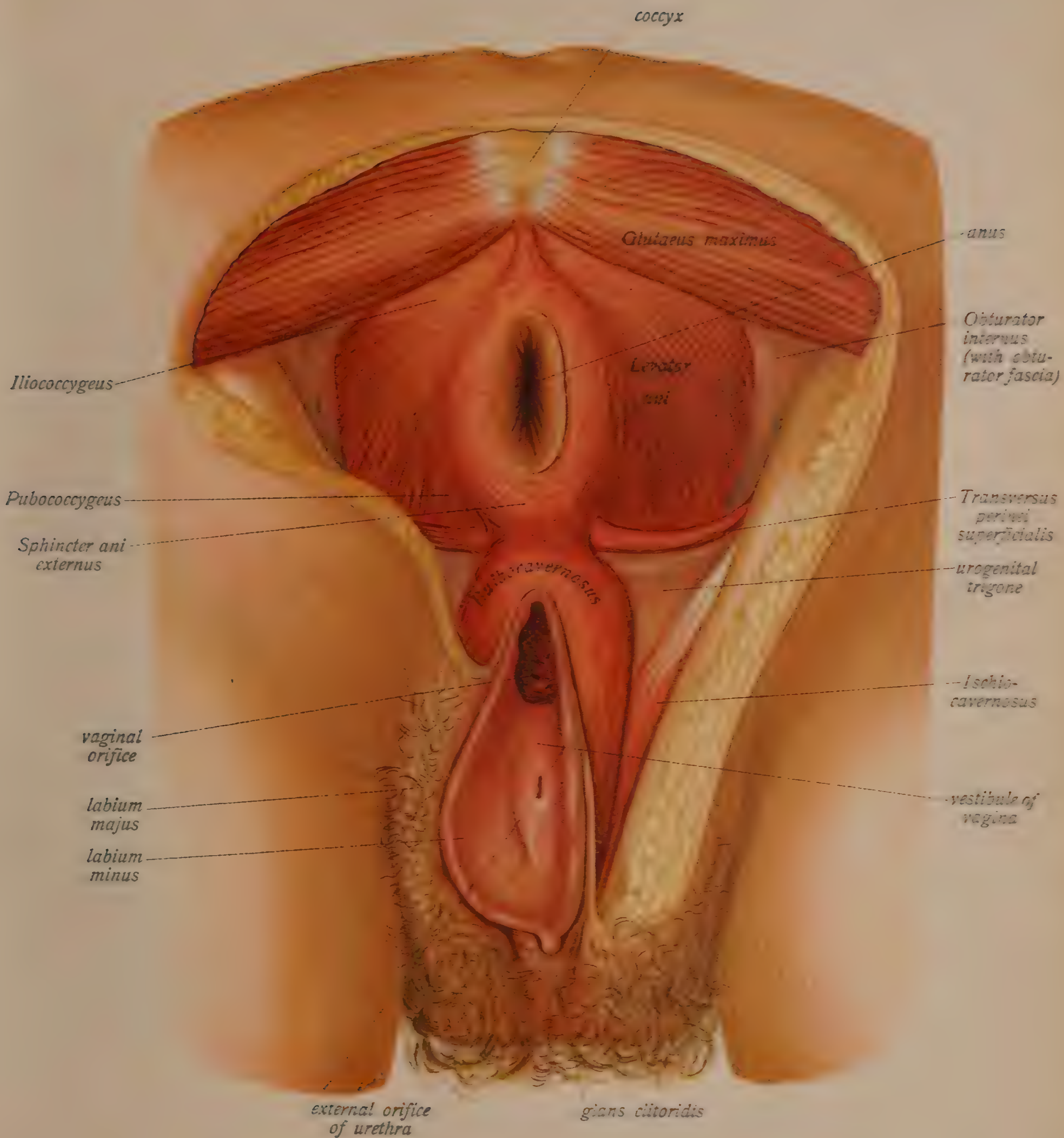

coccyx
Glutaeus maximus
anus
Obturator internus (with obturator fascia)
Levator ani
Iliococcygeus
Pubococcygeus
Sphincter ani externus
Transversus perinei superficialis
Bulbocavernosus
urogenital trigone
Ischio-cavernosus
vaginal orifice
vestibule of vagina
labium majus
labium minus
external orifice of urethra
glans clitoridis

Fig. 516.

The muscle is supplied by the same nerve which innervates the levator ani. The muscle has retrograded to such an extent that it has scarcely any function whatever.

The levator ani, the coccygeus and their fasciæ form a funnel-like closure of the pelvic floor, the cavity of the shallow funnel being directed toward the pelvic cavity and its apex being perforated by the rectum. This structure is known as the *pelvic diaphragm*, and while this is completed posteriorly by the junction of the muscles from either side, it presents an opening anteriorly behind the symphysis which is occupied by the urogenital trigone. Both the coccygeus and the levator ani are retrograded portions of the caudal musculature of the mammalia, and additional remains of such structures are also present in the human subject as the inconstant, poorly developed, and partly tendinous *sacrococcygeus anterior* and *posterior*. These are situated upon the anterior and posterior surfaces respectively of the sacrum and coccyx, and connect the lower sacral and upper coccygeal vertebræ. Like the coccygeus and the levator ani they belong to the skeletal rather than to the visceral musculature.

The **sphincter ani externus** (Figs. 385, 386, 515, and 516) is a single muscle which surrounds the anal orifice. It is 2 to 3 cm. in height and is composed of deep and superficial fibers. The deep fibers surround the lower extremity of the rectum and connect with the fibers of the sphincter ani internus; the superficial fibers are continuous with the deeper ones and decussate in front of the anus in the skin of the perineum, frequently (always in the female) being intimately connected with the posterior extremity of the bulbocavernosus. These superficial fibers also frequently decussate behind the anus and pass to the tip of the coccyx, either independently or by means of the anococcygeal ligament. Some of the fibers also interlace with those of the levator ani.

The space beneath the pubic arch which constitutes the anterior portion of the pelvic outlet, and is left open by the pelvic diaphragm, is closed by the *urogenital diaphragm* (*urogenital trigone*) (Figs. 482, 483, 502, 503, 513, and 514), formed by muscles and fasciæ, only a small opening being left beneath the arcuate ligament of the pubis. The chief constituent of the urogenital trigone is furnished by a lamina of striated muscle which also contains some involuntary musculature, and is termed the *m. trigoni urogenitalis*. Its posterior larger portion consists of two (paired) flat muscles, the *transversi perinei profundi* (Fig. 514), which become continuous with each other in the median line. Each muscle arises from the inferior ramus of the ischium and passes forward and inward to a median raphe in which the fibers of both muscles interlace, and both muscles are also intimately connected with the fascia upon their lower surface, which consequently seems to form an aponeurosis for them. They form the posterior portion of the urogenital trigone, and contain between their fibers the bulbourethral glands, as well as numerous blood-vessels, particularly veins. In the female the greater portion of the muscle passes behind the vagina and is weaker than in the male.

The urogenital trigone also contains the **sphincter urethræ membranaceæ** (Fig. 514), which, in the adult, is more or less fused with the transversus perinei profundus. It is situated in the anterosuperior portion of the urogenital trigone, and consists principally of circular fibers which surround the membranous urethra (see page 137) and are intimately connected with the prostate gland (see page 136). Lateral to these fibers are others in which the circular arrangement is less distinct; they arise from the transverse pelvic ligament, the inferior ramus of the pubis, and the inferior layer of the triangular ligament and unite behind the urethra with each

other and with the anterior fibers of the transversus perinei profundus, many fibers of the muscle also radiating into the surrounding tissues. In the female these external fibers also insert into the anterior and lateral walls of the vagina and may even entirely surround that organ immediately above the bulbus vestibuli. In the female the entire muscle is even more inseparably connected with the transversus perinei profundus than in the male.*

The musculature of the urogenital trigone is supplied by the pudic nerve. Its chief function is the compression of the membranous urethra, and in the male it also compresses the bulbourethral glands.

The **transversus perinei superficialis** (Figs. 511, 515, and 516) is an inconstant, flat, and rather superficial muscle, situated beneath the perineal integument.† It arises from the inner margin of the tuberosity of the ischium or the adjacent portion of the inferior ischiatic ramus, passes almost transversely across the perineum, and unites with its fellow of the opposite side in such a manner that both muscles are connected with the anterior fibers of the sphincter ani externus and the posterior fibers of the bulbocavernosus. The muscle is frequently entirely wanting and is developed differently in different individuals. The direction of the muscle is also somewhat inconstant, but the muscles of the two sides usually form a very obtuse angle which is open posteriorly. It is situated within a sheath of superficial perineal fascia and its course usually corresponds to that of the posterior border of the transversus perinei profundus (*transverse septum* of the perineum, see page 162).

The **ischiocavernosus** (Figs. 491, 515, and 516) is a long, rather flat, paired muscle, which is situated upon the lower surface of the corpus cavernosum penis or clitoridis as the case may be. Owing to the larger size of the corpora cavernosa penis, the muscle is much stronger in the male than in the female. It arises, together with the corpus cavernosum penis (clitoridis), by a flat tendon from the junction of the ischium and pubis or from the contiguous portion of the ischium, runs upon the inferior and lateral surfaces of the corpus cavernosum, and radiates into the inferior and lateral portions of its tunica albuginea. A number of flat fibrous fasciculi frequently pass to the dorsum of the penis to unite with similar fibers from the opposite side, with the fascia penis, and indirectly with the suspensory ligament.

The muscle is in contact with the lateral margins of the urogenital trigone and with the bulbocavernosus, forming a groove with the latter structure. Its origin projects slightly beyond the posterior margin of the trigone.

The transversus perinei superficialis and the ischiocavernosus are supplied by the perineal nerve, the filaments entering the muscles from their perineal aspects.

The ischiocavernosus maintains the erect condition of the penis.

The **bulbocavernosus** (Figs. 490, 515, and 516) exhibits greater sexual differences than any of the muscles of the perineum. In the male (Figs. 490 and 515) it is an arched single muscle which lies upon the inferior surface of the bulb and of the adjacent portion of the corpus cavernosum of the urethra, a raphe extending in the median line throughout almost the entire length of the muscle. Its fibers are situated immediately beneath the superficial fascia and pass obliquely forward and outward; beneath these are sagittal fibers, and the fibers next to the erectile body are

* The musculature of the urogenital trigone is described in many different ways, and some authors do not even recognize a transversus perinei profundus.

† This muscle is, however, covered by the superficial perineal fascia, and in the same region of the perineum there is occasionally also a true cutaneous muscle.

transverse; this last group of fibers, however, is not always distinct and does not usually form a continuous layer. In or adjacent to the median line, the superficial fibers are connected with the sphincter ani externus and the transversus perinei superficialis and terminate anteriorly in two flat, narrow, short, tendinous strips which are inserted into the lateral surfaces of the corpora cavernosa penis and into the contiguous portions of the fascia penis. The raphe of the muscle is connected with the transverse perineal septum.

The bulbocavernosus of the female (Figs. 511 and 516) differs from that of the male principally by being perforated by the vagina, which it surrounds like a sphincter, immediately above the introitus (*sphincter vaginæ*). The greater portion of the muscle is situated upon the posterior and lateral vaginal walls, only the tendinous junction of the two muscles lying in front of the vagina and between it and the urethra. The muscle covers the greater vestibular glands and the bulbus vestibuli, with which its muscular fasciculi are intimately associated. As in the male, the muscle is connected posteriorly with the sphincter ani externus and the transversus perinei superficialis; anteriorly the prolongations of it extend to the crura of the clitoris and also to the other structures in this vicinity, and, it is also in immediate contact with the base of the labia minora.

The bulbocavernosus is also supplied by the perineal nerve. In the male it compresses the urethra and spasmodically forces out the urine and the spermatic fluid; in the female it functions as a sphincter of the vagina and also expresses the contents of the greater vestibular glands.

THE PERINEAL FASCIÆ.

The fasciæ of the perineum (Figs. 480 to 483, 502, 503, 511, and 513 to 516) greatly aid the muscles in forming the pelvic floor. They are arranged in three layers and in certain situations are intimately adherent to the underlying muscles.

The most inferior layer of the pelvic fasciæ is the *superficial perineal fascia.* It comes from the gluteal region and passes from the inner margins of the glutæi maximi over the perineum, and covers the superficial layer of muscles, particularly the inferior surfaces of the bulbocavernosi, ischiocavernosi, and transversus perinei superficialis. The portions of the sphincter ani externus situated immediately beneath the anal integument are not covered by this fascia, but in the posterior portion of the perineum a continuation of it closes in the *ischiorectal fossa.* This fossa is the space between the levator ani and the lateral wall of the true pelvis, which is formed essentially by the obturator internus and the overlying obturator fascia. Its cross-section has the shape of an acute-angled triangle, the acute angle being situated at the origin of the levator ani from the obturator fascia, and it is wider in the female than in the male as a result of the greater width of the female pelvic outlet. It contains a large mass of fatty tissue as well as nerves and vessels (particularly the pudendal vessels), and is widest between the tuberosities of the ischium, becoming narrower posteriorly, and even more markedly so anteriorly. In the region of the external genitalia the superficial perineal fascia becomes continuous with the fasciæ of the scrotum and penis (or of the labia majora and clitoris as the case may be).

The fatty tissue of the ischiorectal fossa is not in immediate contact with the fibers of the levator ani, but is separated from them by a thin layer of fascia, the *inferior fascia of the pelvic diaphragm*, which is not a simple layer of connective tissue, but is to be regarded as a true fascia belonging to the middle layer.

Of especial importance are the layers of fasciæ which, together with the transversus perinei profundus and the sphincter urethræ membranaceæ, form the urogenital diaphragm or trigone (Figs. 511 and 513). These muscles (together with the bulbourethral glands in the male) are invested both upon their superior (posterior) and inferior (anterior) surfaces by layers of fasciæ, the inferior layer (Figs. 511 and 515) being much the stronger, intimately adherent to the muscles and aponeurotic in character. These fascial layers are the superior and inferior fasciæ of the urogenital trigone and they constitute the middle and the superior layers of the fasciæ of the perineum. The two layers are united at their free margins, that is to say, by their postero-inferior margins, forming a thin tendinous strip to which is also attached the superficial perineal fascia (*transverse septum of the perineum*). Antero-superiorly a much more pronounced and stronger line of junction forms the *transverse ligament of the pelvis* (Fig. 514), which connects the upper extremities of both superior rami of the pubes and is parallel with the arcuate ligament of the pubes, from which it is separated by an opening giving passage to the dorsal vessels and nerves of the penis. The superior layer is also continuous with the obturator fascia, and in the male also with the prostatic fascia, and is essentially a portion of the pelvic fascia.

The **urogenital diaphragm,** or **trigone,** formed by the two layers of fascia and the two muscles (particularly by the transversus perinei profundus), is perforated in the male by the membranous urethra, which is situated near the transverse ligament of the pelvis and consequently in the anterior portion of the diaphragm. In the male it also contains the bulbourethral glands and the vessels and nerves of the penis, the latter structures being situated close to the bone. On account of the greater width of the pubic angle, the urogenital trigone of the female is broader than that of the male, and it is further characterized by the fact that it is perforated by the vagina as well as by the urethra. In the male it is in contact superiorly with the prostate and inferiorly with the crura of the penis and the bulb of the urethra, the latter structure being adherent to the inferior layer.

The fascia covering the upper surface of the structures in the pelvic outlet is known as the *pelvic fascia*, which, in addition to the superior fascia of the urogenital trigone, is composed of a visceral layer, the *fascia endopelvina*, and of a parietal layer, the chief portion of which is the *superior fascia of the pelvic diaphragm.*

The *fascia endopelvina* is a relatively thin layer of connective tissue which invests the bladder and prostate, the seminal vesicles and the ampullæ of the vasa deferentia, as well as that portion of the rectum which is situated below the peritoneum (*fascia vesicalis*, *rectovesicalis*, *prostatæ*, etc.).

The *superior fascia of the pelvic diaphragm* invests the upper or pelvic surfaces of the levator ani and the coccygeus. It is strongly reinforced anteriorly by the *tendinous arch* of the pelvic fascia, a tendinous strip which arises from the lower margin of the pubic symphysis and passes downward and backward toward the spine of the ischium.

The superior fascia of the pelvic diaphragm also forms the puboprostatic ligaments in the male and the pubovesical ligaments in the female. The *middle puboprostatic ligament* is a flat ligament, rich in elastic fibers, which passes from the lower margin of the pubic symphysis and the contiguous portions of the tendinous arch to the anterior circumference of the prostate. In the female it is represented by the *middle pubovesical ligament*, which passes to the bladder.

The middle puboprostatic ligaments of the two sides form the lateral boundaries of a deep space, the *pubovesical fovea*, situated behind the symphysis, which gives passage to the dorsal vein of the penis. The *lateral puboprostatic* (*pubovesical*) *ligaments* are situated immediately alongside the middle ones; they arise from the posterior surface of each pubic bone beside the symphysis, and pass to the lateral surfaces of the prostate or the bladder as the case may be.

At the passage of the pelvic viscera (the commencement of the urethra, the vagina, and the rectum) through the pelvic floor the superior fascia of the pelvic diaphragm becomes continuous with the fascia endopelvina which invests these structures. The parietal layer of the pelvic fascia accompanies the vessels and nerves leaving the pelvis for a certain distance, and forms a sort of sheath about them.

Another portion of the pelvic fascia covers the obturator internus and is designated as the *obturator fascia* (Figs. 513, 515, and 516). This fascia accompanies the obturator vessels and nerves into the thigh, forming a funnel-shaped lining for the obturator canal. At the tendinous arch of the levator ani, the obturator fascia becomes continuous with the superior fascia of the pelvic diaphragm, and below the arch the lower portion of the fascia forms the outer boundary of the ischiorectal fossa. The posterior portion of the pelvic fascia, which covers the origins of the piriformes, and the pelvic surface of the sacrum are thin, and terminate above the pelvic outlet.

ANGIOLOGY.

GENERAL ANGIOLOGY.

Angiology treats of the vascular system of the body. The *vessels* constitute a closed system of branching and anastomosing tubes, which vary greatly in caliber and contain either *blood* or *lymph*,* so that, according to their contents, they are differentiated into the *blood-vessels* and the *lymphatic vessels*, both of which possess a common central organ, the *heart* (*cor*). This latter structure consists essentially of a hollow muscular tube, and serves as a propulsive organ for the blood, the vessels which carry the blood away from it being known as *arteries*, while those that return the blood are termed *veins*. The arteries and the veins are connected throughout the entire body by a system of microscopic vessels, the *capillaries*, which are directly continuous upon the one hand with the finest arterial branches and upon the other with the smallest venous radicals. The lymphatic system, however, seems to be an appendage of the venous portion of the circulation, and, in contrast to the blood-vessels, it consists of but a single variety of large vessels, in which the stream is centripetal, as in the veins. It also possesses lymph capillaries.

All portions of the vascular system, the heart, the arteries, the veins, and the capillaries, are lined by a common coat, the *tunica intima*. The heart, the arteries, and the veins also possess a muscular coat, the *tunica media* (*muscularis*), which attains its greatest development in the heart, and an outer coat, or *tunica adventitia*. While the heart possesses a most complicated structure owing to the development in it of a series of special mechanisms (see page 170 *et seq.*), the remaining blood-vessels are approximately cylindrical tubes, the caliber of which gradually increases or decreases as they give off or receive branches, so that both the arteries and the veins attain their greatest caliber in the neighborhood of the heart. The capillaries alone exhibit an approximately uniform caliber.†

The blood passes from the heart into the arteries, is conveyed by them to the capillaries, and is returned to the heart by the veins. The arteries are consequently the vessels which first experience the impact of the muscular force of the heart, and, as might be expected, they possess much stronger walls than the accompanying veins. The larger arteries are further characterized by their richness in elastic fibers, and consequently have a yellowish appearance. In the vicinity of the heart the thickness of the large arterial tubes is many times greater than that of the large venous trunks, but the caliber and number of these venous trunks is greater than that of the large arteries, an arrangement which facilitates the return of the venous blood to the heart. The same purpose is served by the valves which are present in many of the veins as sickle-shaped elevations

* The lymph circulating in the intestinal lymphatic vessels is known as chyle.

† This does not mean that all the capillaries of the body are of exactly the same caliber. On the contrary, both narrow capillaries (as in the muscles) and wider ones (as in the lungs) occur. Within the same capillary area, however, the caliber of the capillaries is approximately the same.

of the intima projecting into their lumen, and always giving the blood a centripetal direction. Still more markedly developed are the valves in the lymphatic vessels, which are so closely placed that a distended lymphatic vessel has the appearance of a string of pearls. The arteries, however, exhibit no such valvular formations except at their origin from the heart (see page 172).

A vascular tube may divide into two branches of equal size, as is the case with the abdominal aorta, which divides into the two common iliacs, and the pulmonary artery, which subdivides into the right and left pulmonary branches; similarly the two innominate veins, which are approximately of the same caliber, unite to form the superior vena cava. On the other hand, small branches may be given off from quite large arteries, or small venules may terminate in large venous trunks, but, as a general rule, the smaller the vessel, the greater the number of ramifications.

The branches of a vessel usually pursue the same general direction as that of the parent trunk; if this is not the case and the vessel runs in the opposite direction, it is spoken of as a recurrent artery.* If the vascular branches run parallel to the trunk from which they arise for a considerable distance, they are referred to as collateral vessels.

Arterial anastomoses may be capillary, precapillary, or those involving the smaller or middle-sized arteries. The anastomoses of the smaller or middle-sized arteries are also referred to as communicating branches; they are relatively infrequent (brain), while precapillary anastomoses, formed by arteries just before they become capillaries, are present in most situations in the body. In those parts of the body in which such anastomoses are absent, as in the kidney, the liver, and certain portions of the brain, the arteries are known as *terminal arteries*. If the precapillary anastomoses are very numerous they constitute what are termed *retia vasculosa* (*arteriosa*)*;* these are common in the neighborhood of joints and are consequently also known as *retia articularia.* Narrow-meshed vascular networks are also termed *plexus vasculares*, and occur more frequently in the venous than in the arterial system. A vascular network interrupting the continuity of an artery (or vein) is called a *rete mirabile*, but such structures occur in the human subject only in the glomeruli of the kidney.†

In the venous system anastomoses of every variety are much more frequent, particularly the formation of plexuses, and anastomoses of the middle-sized veins are quite common, a condition in marked contrast to that obtaining in arteries of the same size. The lymphatic vessels also form a large number of lymphatic plexuses.

Large arterial trunks are never situated upon the surface of the body, but are usually deeply placed between the muscles. The larger venous branches, however, are very frequently found immediately beneath the skin in the subcutaneous connective tissue, forming the so-called *cutaneous veins*, in contrast to which there are also *deep veins* which pursue the same course as the corresponding arterial branches and are consequently also designated as the *venæ comitantes*. They are frequently found in pairs accompanying the arteries of middle caliber (this being the rule in the extremities), so that the number of the veins is considerably greater than that of the arteries, especially in the extremities, which also contain the majority of the larger cutaneous veins.

* Such vessels are usually arteries.

† In many of the mammalia the retia mirabilia play an important rôle.

The arteries, their venæ comitantes, and frequently also the accompanying nerves, are surrounded by common fibrous sheaths, the vascular sheaths or *vaginæ vasorum.* The vessels supplying the walls of the vessels are known as *vasa vasorum,* and, as a rule, they do not proceed directly from the artery which they nourish, but from a neighboring vessel. They are never situated in the intima, but occur in the media and adventitia, or, in vessels of smaller caliber, only in the adventitia. The heart possesses vasa vasorum of considerable size for the nutrition of its musculature.

Markedly dilated venous spaces are referred to as *venous sinuses.* The *sinuses of the dura mater* have no true wall, but run in grooves in the bones between two layers of the dura, and their connections with the veins of the diploë or of the scalp are known as *emissaries. Corpora cavernosa* are erectile structures of the vascular system which consist of numerous communicating venous spaces separated by trabeculæ, so that the erectile bodies have a spongy structure. They are usually invested by a pronounced fibrous tunic (the albuginea).

The name *glomus* is used to designate peculiar plexuses of fine arteries or veins, which are found as isolated structures in certain regions of the body and have no connection with the ramifications of the neighboring vessel. The so-called *carotid gland,* glomus carotideum,* is situated at the bifurcation of the common carotid artery, and a similar structure, the *coccygeal* (*Luschka's*) *gland,* or *glomus coccygeum,* is located at the termination of the middle sacral artery.

The lymphatic system also exhibits special formations, the *lymphatic glands* (*lymphoglandulæ*) or, as they are more appropriately called, *lymphatic nodes.* These are variously shaped bodies resembling glands in their general appearance, and their size usually varies between that of a pea and that of a bean. They are round or more frequently elongated structures, and consist of adenoid tissue. Since they are interposed in the lymphatic stream they possess both efferent and afferent lymphatic vessels.

The blood-vessels develop from the connective-tissue portion of the mesoderm, the so-called mesenchyme. The cellular lining of the vascular system is consequently endothelial and not epithelial, as is the case in the visceral tract. In the higher animals the heart arises very early at a time when the branchial gut† is still spread out upon the yolk-sac, and consequently appears originally as a paired rudiment situated to either side of the gut. It soon acquires intimate relations with the embryonic body cavity,‡ whose epithelium becomes the pericardium and also produces the myocardium. In correspondence with the segmental arrangement of the embryonic mesoderm § the first vascular branches exhibit a segmental character which is subsequently retained only in certain situations (the intercostal and lumbar arteries).

* These structures were formerly regarded as glands [but according to recent observations they seem to be accessory portions of the sympathetic nervous system. At all events, they consist primarily of a mass of cells which resemble greatly sympathetic ganglion cells; later the cell mass becomes extensively invaded by connective tissue and highly vascularized, the blood-vessels being arranged in a close plexus or glomus.—Ed.].

† For further details see the general introduction to the third volume.

‡ For further details see the general introduction to the third volume.

§ For further details see the general introduction to the third volume.

SPECIAL ANGIOLOGY.

THE BLOOD-VASCULAR SYSTEM.

THE CIRCULATION.

The blood-vascular system includes the heart, the arteries, the capillaries, and the veins. During life the blood which these structures contain is in a state of constant motion, and since the direction of the motion is always the same, it is known as the *circulation of the blood.* In the human subject after birth there are two separate circulations, the so-called *greater* or *systemic circulation*, which serves to supply the blood to all portions of the body, and the *lesser* or *pulmonary circulation*, by which the blood is provided with fresh oxygen. The aerated bright red blood is called *arterial blood*, because it is found in the arteries of the systemic circulation, and the dark red blood, rich in carbon dioxide and poor in oxygen, is spoken of as venous blood because it occurs in the veins of the systemic circulation. In the pulmonary circulation, however, the arteries contain "venous" and the veins "arterial" blood.

Since the heart furnishes the propulsive power for both circulations, it consists of two separate halves; and since the blood from the veins is received into special cavities which may be shut off from those portions of the heart giving off the arteries, the heart consists of four separate chambers. Those receiving the blood from the veins of both the general and pulmonary circulations are called *auricles* or *atria*, while those from which the arteries proceed are termed *ventricles.* There are two ventricles, a left and a right, and also a left and a right atrium. The atrium and ventricle of the same side communicate by an *atrioventricular orifice* (*ostium venosum*) provided with a valvular mechanism, while the cavities of opposite halves of the heart are completely independent of each other.

The greater or systemic circulation commences in the left ventricle (Fig. 517), passes thence to the aorta, the great arterial vessel, which gives off all the main branches for the body, and returns to the right atrium by the superior and inferior venæ cavæ, which receive all the veins of the general venous system. The lesser or pulmonary circulation begins in the right ventricle, passes through the pulmonary artery and its branches to both lungs, and returns to the left atrium through the pulmonary veins. The blood consequently pursues the following path: it passes from the left ventricle of the heart into the aorta and its branches, and is thus distributed to almost all of the organs and tissues of the body, finally reaching the capillaries, where it gives up its oxygen. Having thus become "venous" the blood is returned to the right atrium, passes through the right ostium venosum into the right ventricle, and thence through the pulmonary artery into the capillaries of the lung, where it takes up a fresh supply of oxygen. As "arterial" blood it is then carried by the pulmonary veins to the left atrium of the

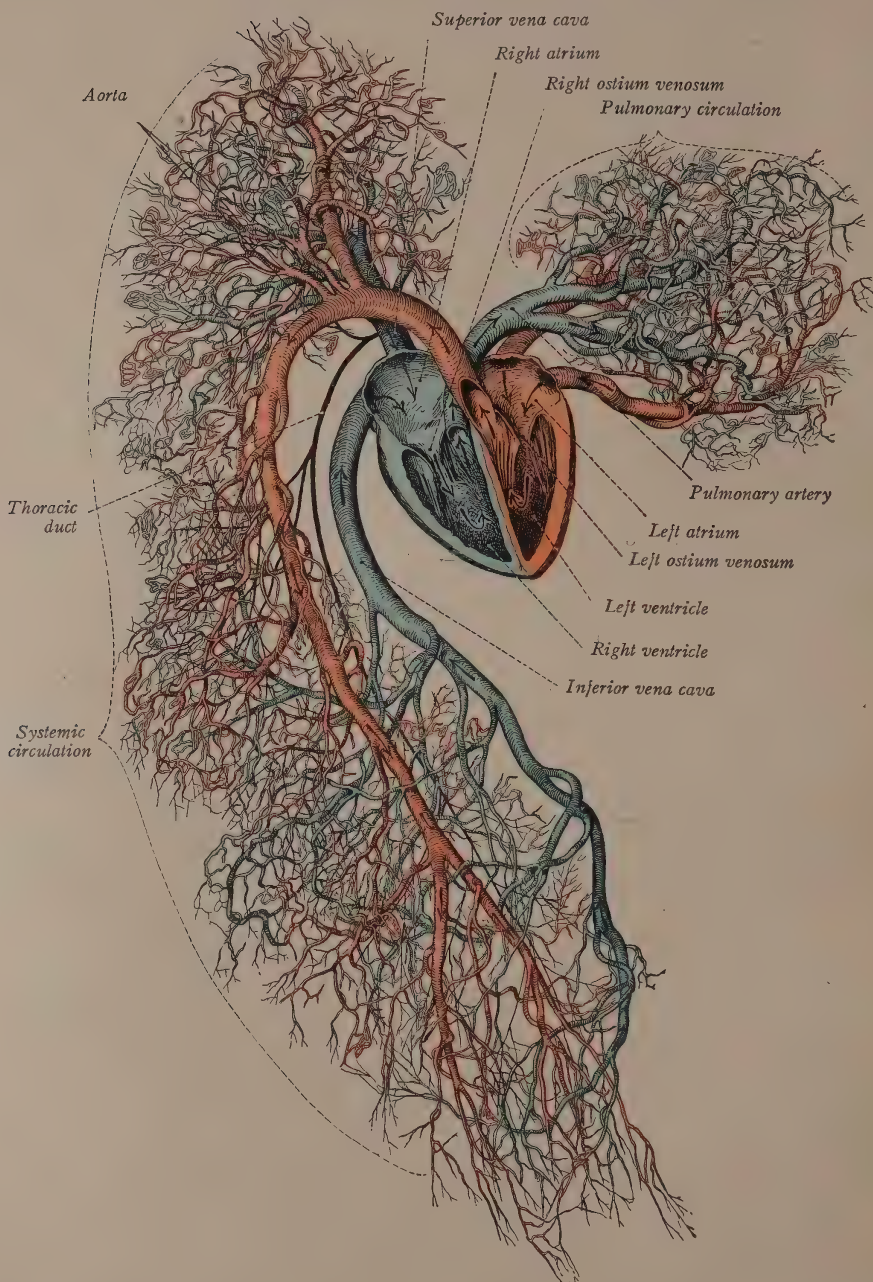


FIG. 517.—Diagram of the circulation. The vessels which contain arterial blood are represented in red, those containing venous blood in blue. Lymph vessels are black.

heart and then passes through the left ostium venosum into the left ventricle, thus completing the circulatory path.

The systemic circulation is much longer than the pulmonary one. The sum total of the cross-sections of the veins of the systemic circulation is considerably larger than the cross-section of the aorta, while in the pulmonic system, the sum total of the cross-sections of the veins does not exceed that of the pulmonary artery.

In addition to its connection with the lymphatic system, the systemic circulation also holds relations in the liver with the portal circulation, *i. e.*, the blood which has already passed through one set of capillaries in the intestinal wall (see page 62) is conducted by the portal vein to the liver, where it again traverses a set of capillaries, enters the hepatic veins, and finally reaches the heart through the inferior vena cava.

THE FETAL CIRCULATION.

The circulation in the fetus differs in certain respects from that of the adult. Until the moment of birth the pulmonary circulation, although present anatomically to a certain degree, plays no physiological rôle, but the blood of the fetus is arterialized by the oxygen of the maternal blood in a special organ, the placenta, which is formed by the union of the membranes of the fetus with the uterine mucosa of the mother. The fetus is connected to the placenta by the umbilical cord, and its blood reaches the placenta through the *umbilical arteries*, the lateral umbilical ligaments of the adult (see page 121), which are indirect but very large branches of the aorta; the blood from the placenta passes to the fetus through the single *umbilical vein*, which becomes the round ligament of the liver in the adult (see page 58). This vein passes to the inferior surface of the liver and some of its contained arterialized blood passes through the liver, through what is subsequently the portal vein, while the remainder is conducted by the *ductus venosus* (*Arantii*), the ligamentum venosum of the adult (see page 58), directly into the inferior vena cava and thus reaches the right auricle. In the fetus the right auricle communicates with the left auricle through a round opening, the *foramen ovale*, which subsequently becomes the fossa ovalis (see page 177), and through this foramen the blood which enters the right auricle by way of the inferior vena cava is directed into the left atrium by the *valve of the vena cava* (Eustachian valve, see page 177), which is situated between the orifice of the inferior vena cava and the right ostium venosum and consequently prevents this current from passing into the right ventricle. The blood after traversing the left atrium passes through the left ostium venosum into the left ventricle and thence into the aorta. That part of the blood which enters the right ventricle in spite of the Eustachian valve passes into the pulmonary artery, but only a very small portion can pass to the lungs, since the pulmonary vessels are but slightly patulous before birth. By far the greater portion of the blood in the pulmonary artery reaches the aorta through the *ductus arteriosus* (*Botalli*), which later becomes the ligamentum arteriosum. In the fetal circulation there is consequently a mixture of the arterial and venous bloods.

At the moment of birth, with the first inspiration of the newborn, the pulmonic and the systemic circulations become separated. This is brought about by the closure of the foramen ovale. A valve, the *valve of the foramen ovale* (see page 179), develops upon the left side of the

FIG. 518.—The heart seen from in front, the sternocostal surface.

FIG. 519.—The heart seen from below and behind, the diaphragmatic surface.

FIG. 520.—The right atrium and ventricle opened along the right border of the heart.

FIG. 521.—The right ventricle and pulmonary artery opened by an incision on the anterior surface and along the right border of the heart.

FIG. 522.—The left ventricle and aorta opened by incisions in the middle of the left ventricle and along the anterior sulcus. *= The membranous septum.

FIG. 523.—The left ventricle and atrium opened by an incision along the middle of the ventricle.

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fetal interatrial septum, and during fetal life is projected into the left atrium by the blood-stream from the right atrium so long as no blood reaches the left atrium through the pulmonary veins. With the first inspiration of the newborn the lungs suddenly expand, and the capillary system, which was previously greatly compressed, now becomes patulous. The blood in the pulmonary artery now flows into the pulmonary system (no longer passing laterally through the ductus arteriosus) and is returned to the left atrium by the pulmonary veins, and since this blood enters the left atrium under much greater pressure* than that under which the systemic blood enters the right atrium, the valve of the foramen ovale is forced against the foramen and gradually obliterates it by becoming adherent with its margins. All the blood entering the right atrium from the systemic veins must now pass through the right ostium venosum, and the conditions obtaining in adult life are consequently established.

THE HEART (COR).

THE GENERAL RELATIONS OF THE HEART.

The heart is a short, almost conical, thick-walled, muscular tube, whose upper, broad, attached extremity is known as the *base*, while the lower freely movable portion is termed the *apex*. It presents two surfaces which are distinctly marked off from each other, except at the left border, where they are directly continuous even in the empty organs. One surface is convex and directed forward and somewhat upward; it lies behind the body of the sternum and the adjacent costal cartilages and is called the *sternocostal surface* (Fig. 518). The other surface is also convex, but only to a slight degree, and is directed backward and downward; since it is in relation with the central tendon of the diaphragm it is termed the *diaphragmatic surface* (Fig. 519).

Above the base of the heart are situated the atria and the two arteries which are given off from the ventricles, while below it is the ventricular portion. The base of the heart is limited externally by a circular groove, the *coronary sulcus* (Figs. 518 and 519), which is interrupted anteriorly and contains the nutritive vessels for the viscus. A longitudinal groove upon the anterior and another upon the posterior surface of the heart, the *anterior* and *posterior longitudinal sulci* (Figs. 518 and 519), indicate the line of separation of the two ventricles, and also contain the main branches of the vessels intended for the nourishment of the heart. Both these

* The pressure under which the blood from the pulmonary veins flows into the left auricle is greater than that of the blood of the right auricle for the reason that the blood from the systemic circulation has passed through a longer distance and also through a much narrower set of capillaries than has the blood of the pulmonic circulation.

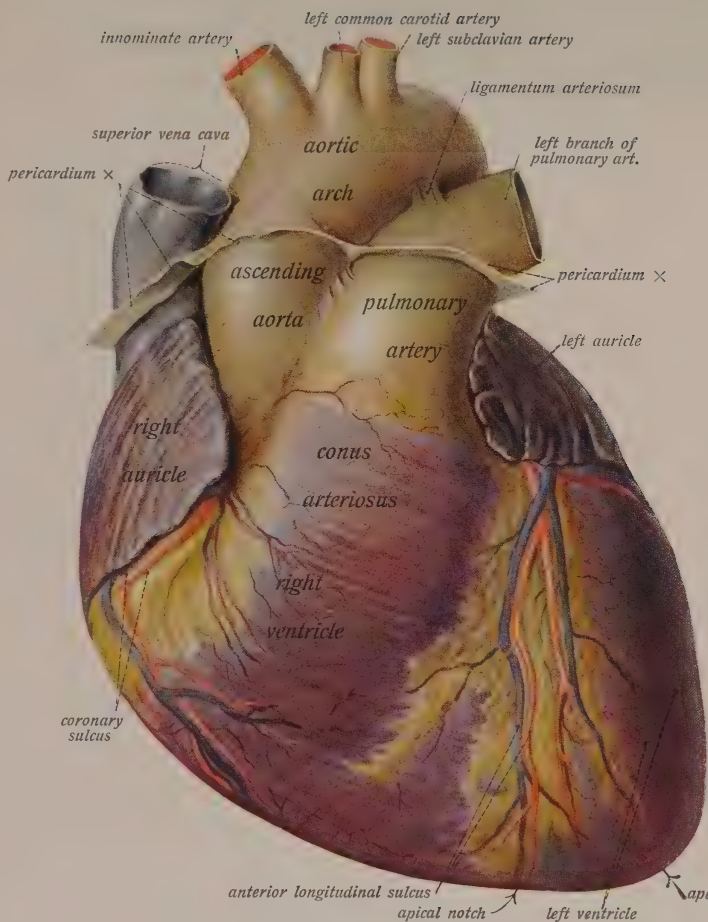

Fig. 518.

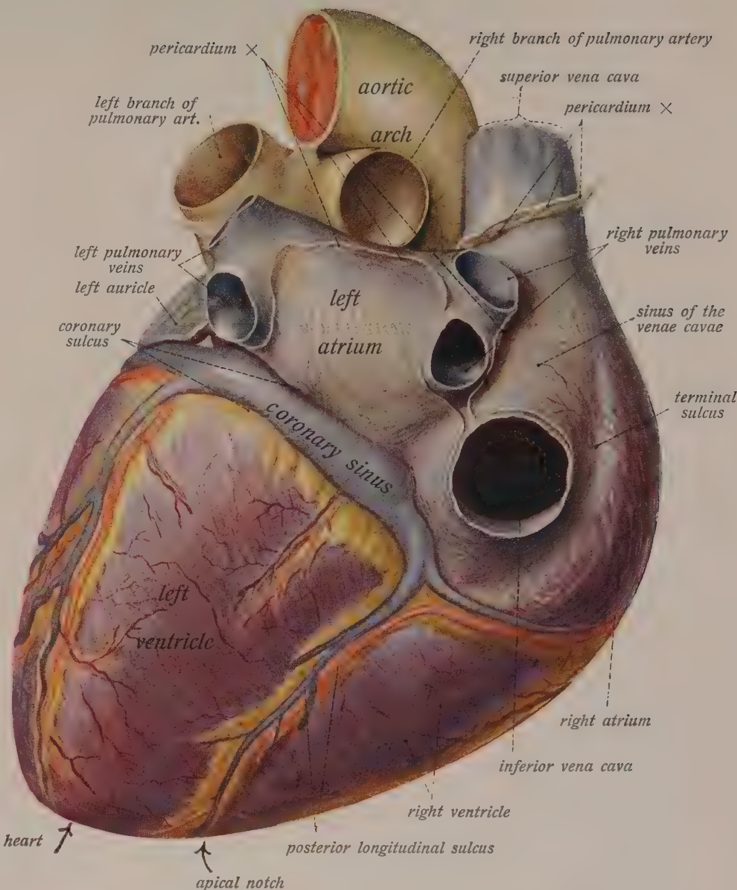

Fig. 519.

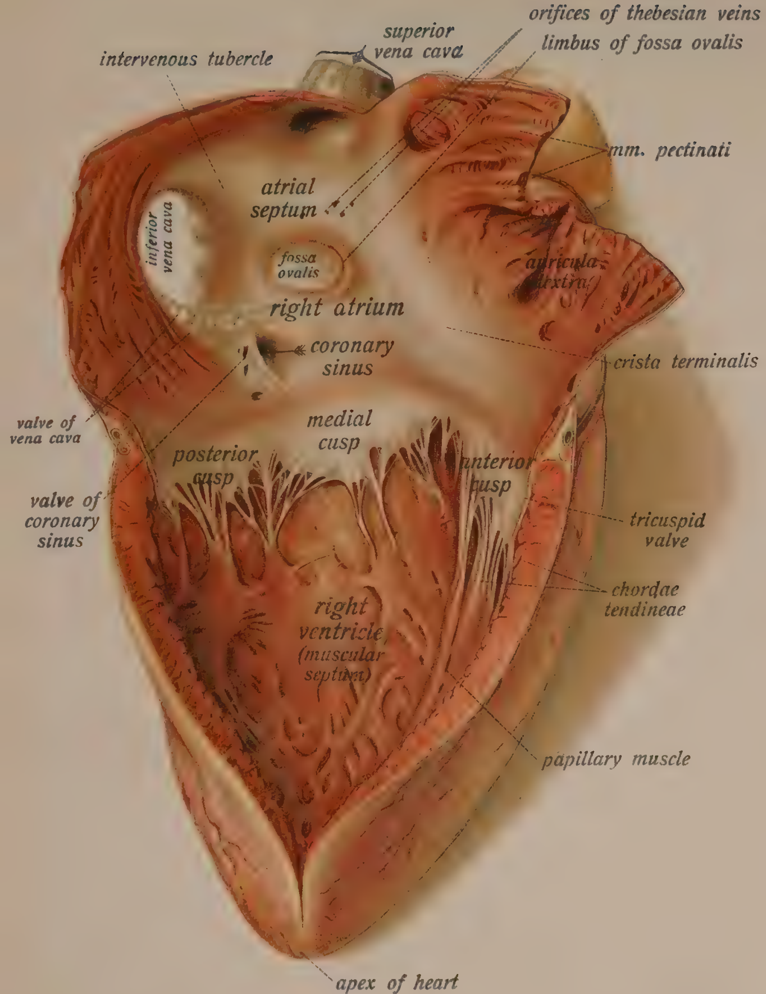

Fig. 520.

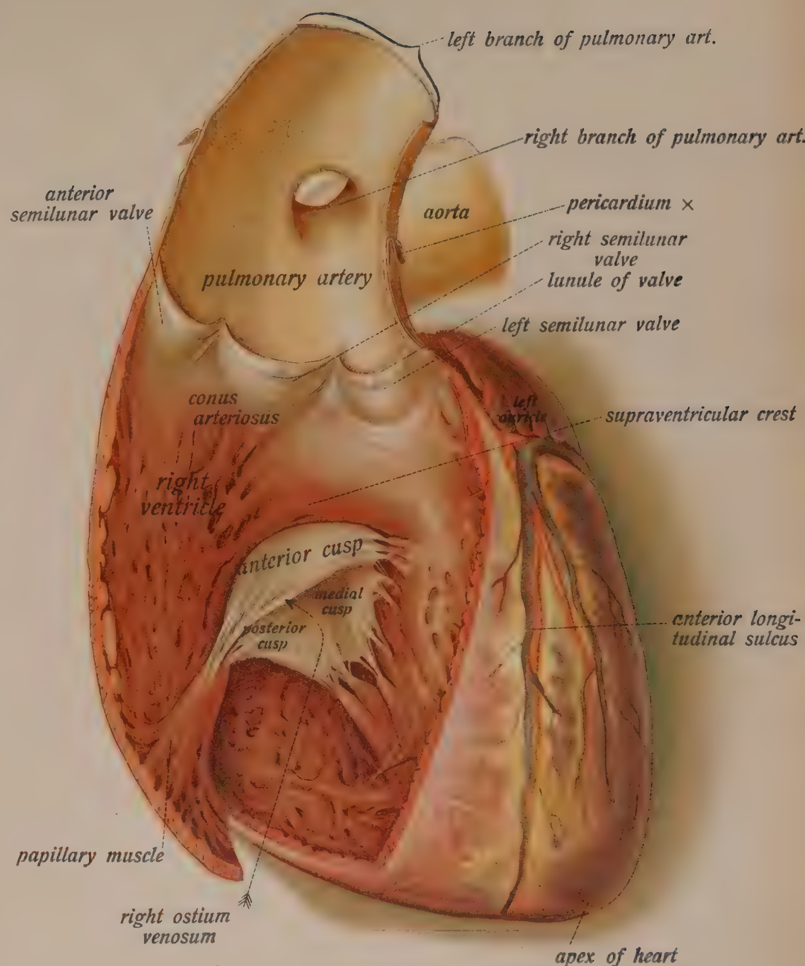

Fig. 521.

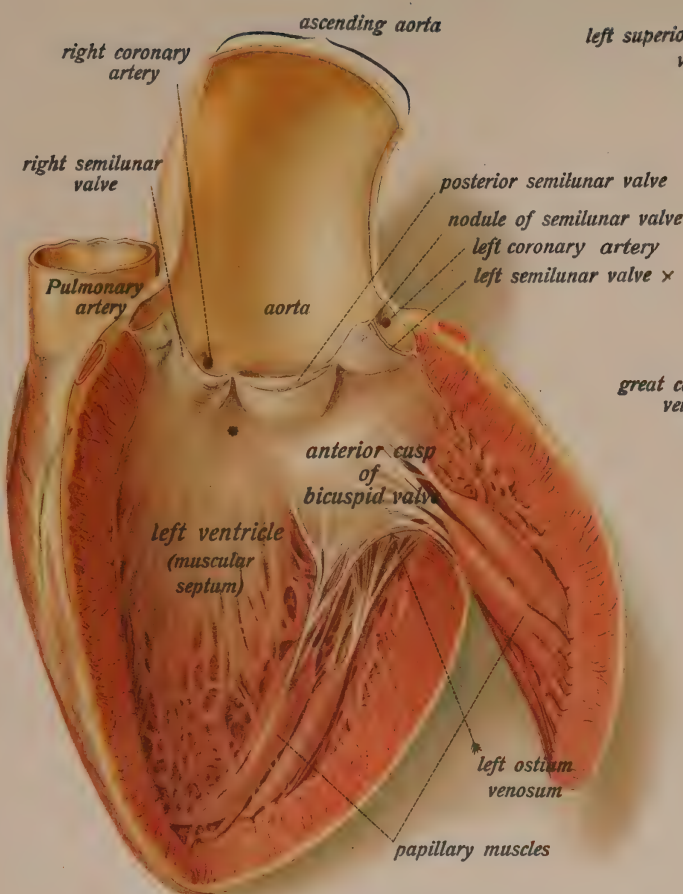

Fig. 522.

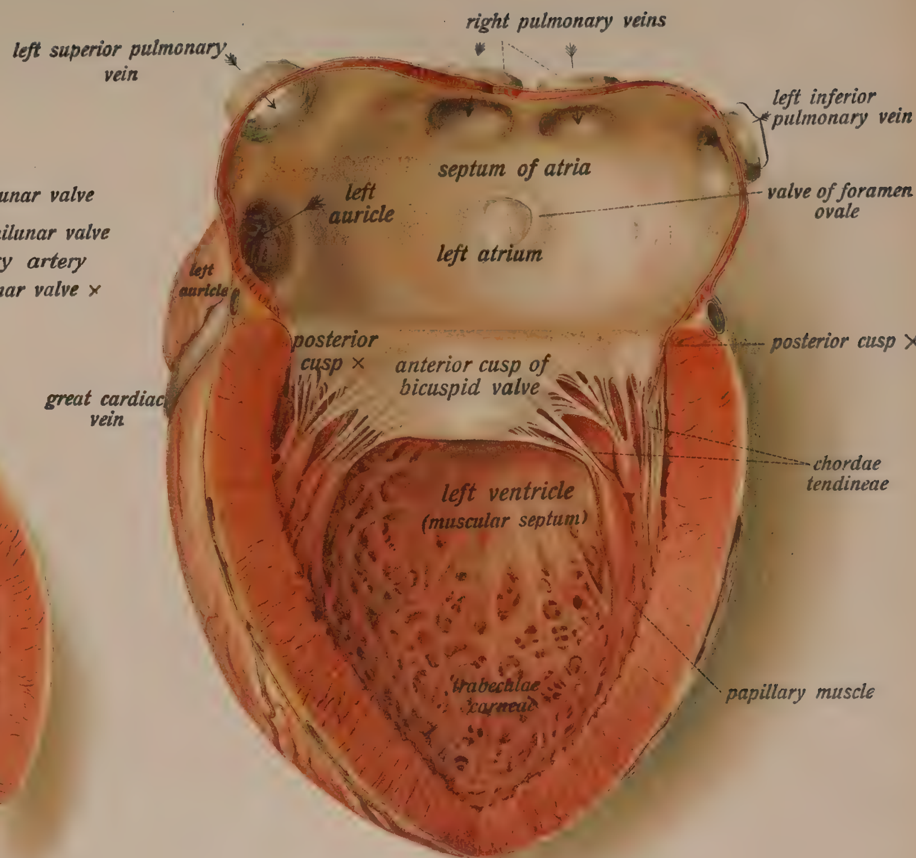

Fig. 523.

sulci unite to the right of the apex to form the apical notch (Figs. 518 and 519), which is not always distinctly indicated.

The heart is not symmetrically placed in the body, since about two-thirds of the viscus lies to the left of the median plane. The longitudinal axis is oblique, passing from behind forward, from above downward, and from right to left, and the ventricles are consequently nearer the anterior thoracic wall than are the atria. At the same time the cardiac axis seems to be rotated, so that the left side of the heart is more posterior and the right more anterior. As a result of this oblique position of the cardiac axis, the longitudinal sulci which indicate the demarcation of the ventricles are neither exactly longitudinal nor exactly median, and the four main divisions of the heart, and the vessels coming off from the organ, consequently hold the following relations to the two cardiac surfaces (Figs. 518 and 519). The anterior longitudinal sulcus begins at the base near the left border of the heart and passes over its anterior surface to terminate to the right of the cardiac apex. The coronary sulcus is interrupted upon the anterior surface of the heart by the roots of the two great vessels, particularly by that of the pulmonary artery, which arises from the right ventricle by means of the *conus arteriosus* and conceals the actual root of the aorta. By far the greater portion of the anterior surface below the coronary sulcus (and the roots of the vessels) is taken up by the right ventricle, which extends from the anterior longitudinal sulcus to the right border of the heart, which is sharply defined in the empty viscus. The relatively small portion of the sternocostal surface to the left of the anterior longitudinal sulcus is formed by the left ventricle. Upon the anterior cardiac surface, above the coronary sulcus, is seen a portion of the right atrium, especially the entire right auricle, the tip of which lies upon the adjacent ascending aorta. To the left and above the coronary sulcus is to be seen the corresponding left auricle, which is applied to the left margin of the pulmonary artery, and above the right auricle, to the right and partly concealed by the ascending aorta, is situated the superior vena cava.

The diaphragmatic surface of the heart is traversed by the coronary sulcus, which is uninterrupted in this situation and contains the great cardiac vein, or rather the coronary sinus (there is also an arterial branch to the right). The posterior longitudinal sulcus lies slightly to the right of the middle line, and terminates to the right of the apex, as does the anterior longitudinal sulcus upon the anterior surface, so that the apex of the heart is formed exclusively by the left ventricle. Corresponding to the course of the longitudinal sulcus the left ventricle takes up the greater portion of the posterior surface of the heart. Above the coronary sinus both atria may be seen, especially the left with the base of its auricular appendix, and the terminations of the four pulmonary veins; the *sinus of the venæ cavæ* of the right atrium together with the entrances of both cavæ are also visible, and are marked off from the remainder of the atrium by the shallow *terminal sulcus*. Above the left atrium is the left branch of the pulmonary artery.

The cavity of the heart is subdivided into four separate compartments, the right and left atria and the right and left ventricles. Each half of the heart consists of an atrium and a ventricle, and the two halves are separated by a septum which is further differentiated into the *atrial* and the *ventricular septa*. Each atrium is composed of two portions, the *venous sinus*,* for the reception of the veins, and the atrium proper, with an irregularly conical appendage, the auricle.

* The venous sinus is described only in the right auricle; it is, however, also present in the left.

FIG. 524.—The musculature of the heart seen from in front. A portion of the superficial layer has been removed from the wall of the right ventricle to expose the middle layer.

FIG. 525.—The musculature of the heart seen from behind. A portion of the superficial layer has been removed from the wall of the left ventricle to expose the middle layer.

FIG. 526.—The superficial musculature of the heart, seen from the apex.

FIG. 527.—The four ostia of the heart seen from above, after removal of the atria. The valves are shown closed. *= Intermediate cusp.

All four cavities of the heart are irregularly shaped, and, in spite of their varying shapes, each contains the same amount of fluid. The walls of the atria are thin, while those of the ventricles are considerably thicker (Figs. 520 and 523), and the atria and ventricles are connected by openings which are termed the *ostia venosa* (*atrioventricular orifices*). These are rounded and elongated, and are guarded by segmented valves which project into the ventricles. The exits of the arteries from the ventricles are more nearly circular, and each one is guarded by three semilunar valves which open into the lumen of the artery.

The heart is completely surrounded by the pericardium and consequently it does not come into direct contact with the neighboring organs, but its relations are dependent upon those of the pericardium * (see page 181).

If the outline of the heart were projected upon the anterior thoracic wall, the right border of the figure would be almost vertical, extending parallel to the right side of the sternum about midway between the parasternal and sternal lines (see page 103) from the upper margin of the third to the lower margin of the fifth costal cartilage (Figs. 451, 452, 454, and 460). The lower border of the projection outline would run from the latter point to the fifth left intercostal space between the parasternal and mammillary lines, and from this point the left border would pass to the second left intercostal space between the sternal and mammillary lines, and the superior margin from there to the upper margin of the third left costal cartilage.

The left ostium venosum is situated behind the junction of the fourth costal cartilage with the sternum; the right one, behind the lower portion of the body of the sternum at the level of the fourth intercostal space. The aortic orifice lies behind the middle of the body of the sternum at the level of the third intercostal space, and the pulmonary orifice is behind the insertion of the third left costal cartilage.

The cardiac wall consists of three layers. The most external is the visceral layer of the pericardium (see page 181) and is termed the *epicardium*. Beneath this serous layer, at least in the adult heart, there are marked accumulations of fat which are particularly pronounced in the sulci and in the neighborhood of the cardiac apex, but in those situations in which this fatty tissue is absent, the epicardium is firmly adherent to the second layer of the cardiac wall, the *myocardium*.

The *myocardium*, the actual cardiac muscle, forms the middle and by far the thickest layer of the cardiac wall; it is particularly marked in the ventricles, where it constitutes more than seven-tenths of the thickness of the ventricular wall. Its elements are peculiar striated muscular

* For further details in reference to the relations of the heart the reader is referred to the text-books and atlases of topographic anatomy.

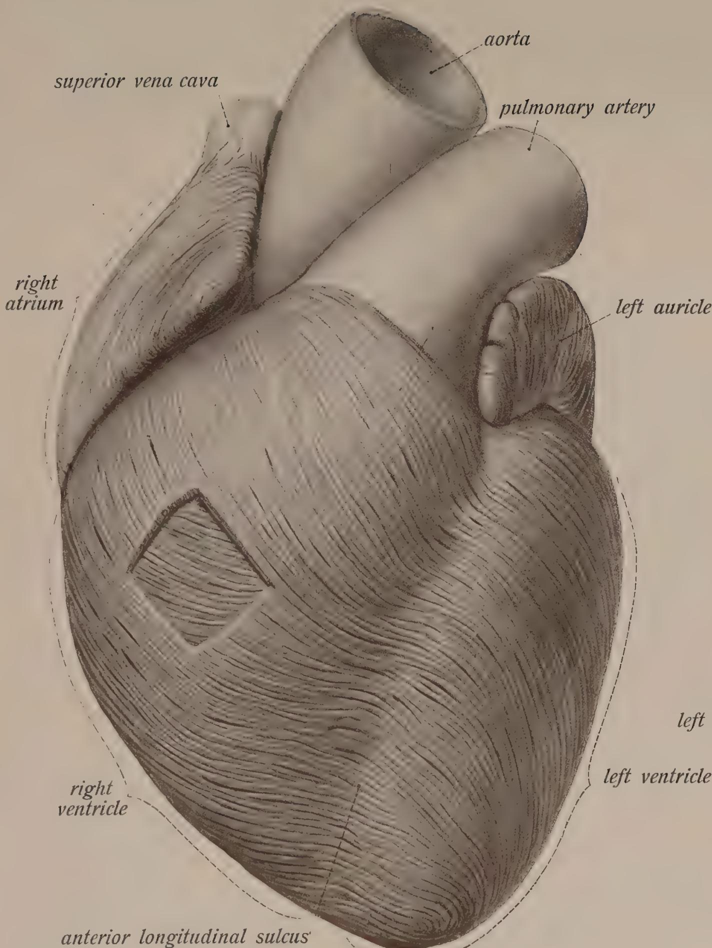

Fig. 524.

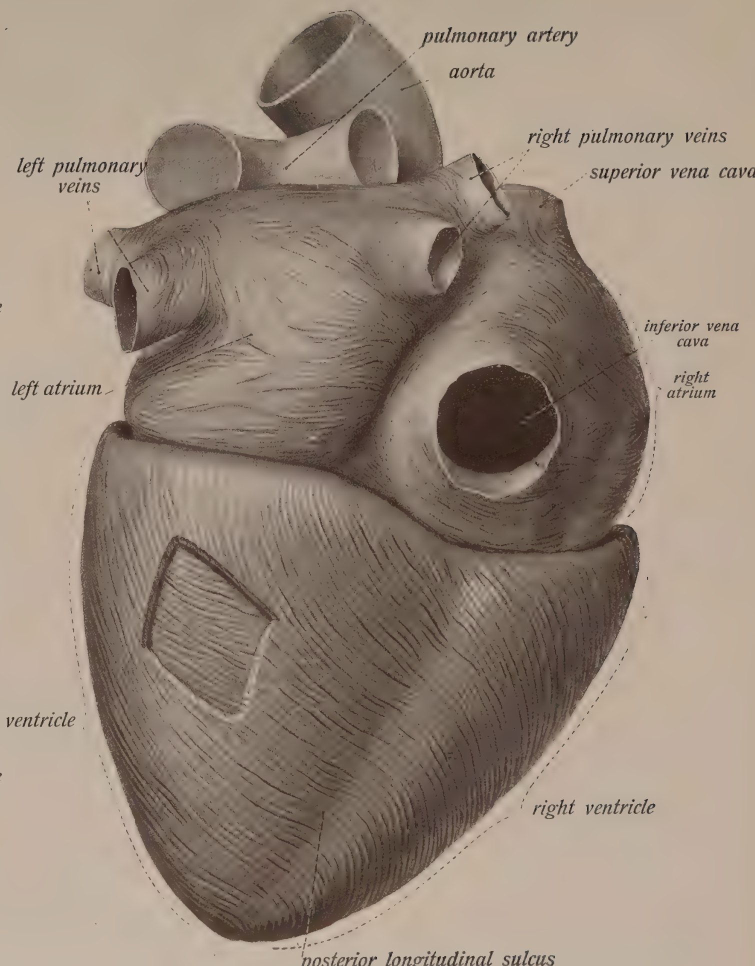

Fig. 525.

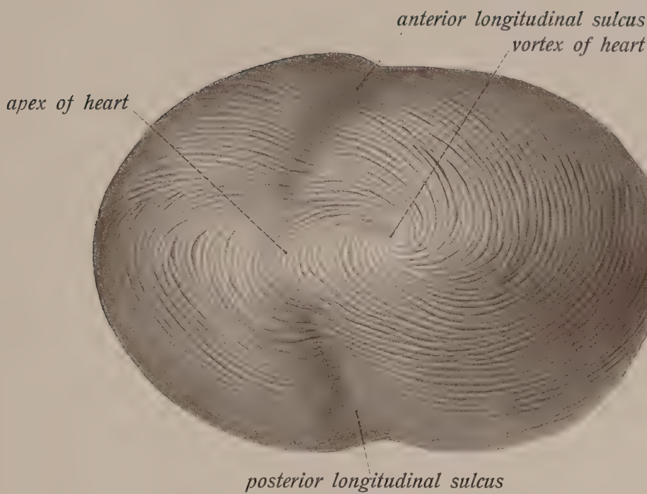

Fig. 526.

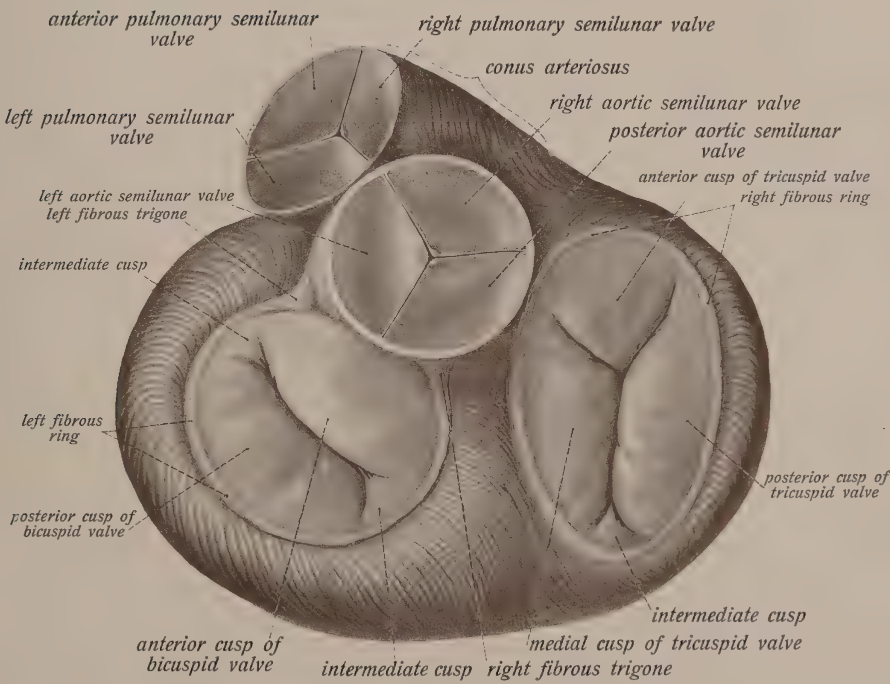

Fig. 527.

fibers which are arranged in fasciculi and laminæ in an extremely complicated manner. Only the course of the principal muscular layers will consequently be described.

In the atria the musculature of the auricular appendages is considerably thicker than that of the venous sinuses. The appendages possess internal circular fibers and external longitudinal ones, the latter being parallel to the longitudinal axis of the appendix. The venous sinuses possess internal longitudinal and external circular fibers, and flat fasciculi bridge over the sulcus between the two atria, especially upon the anterior wall. Circularly arranged fibers are found at the terminations of the veins (upon the walls of which isolated striated muscular fibers are continued), and in other situations the circular fibers frequently pass directly into the oblique ones. The deeper fibers arise partly from the *fibrous rings* of the ostia venosa, especially upon the left side, and sink deeply into the substance of the atrial septum, which is formed by these fibers except in the area designated as the membranous portion. The deep fibers of each atrium are essentially distinct from those of the other, while many of the superficial fibers are common to both atria; the musculature of the atria, however, is almost entirely independent of that of the ventricles.*

The superficial fibers of the ventricles are similar to those of the atria, in that they also bridge over the sulci and to a great extent are common to both ventricles, but the great majority of the muscle fibers of the ventricle, particularly those of the more powerful deeper layers, are completely independent in each half of the heart. The musculature of the ventricles is much stronger than that of the atria, and that of the left ventricle is much stronger than that of the right.

The superficial ventricular musculature (Figs. 524 and 525) consists essentially of flat fasciculi, which arise from the region of the base of the heart and proceed to the region of the cardiac apex, in such a manner that they are arranged transversely or obliquely in the right ventricle and more longitudinally in the left. Some of these fibers penetrate into the ventricular septum, but the majority bridge over the longitudinal sulci, and at the apex of the heart form a whorl, the *vortex* of the heart (Fig. 526), from which fibers pass into the deeper portion of the left ventricle and take part in the formation of its internal muscular layer. In addition to the superficial muscular layer the left ventricle also contains a middle and a deep layer. The middle layer (Fig. 525) is by far the stronger and its chief direction is transverse; the lamellæ of which it is composed, however, frequently exhibit an irregular direction and partly interlace with each other. The innermost layer is situated immediately beneath the endocardium, and consists of irregularly arranged fasciculi which form certain structures upon the inner surface of the ventricular wall which will subsequently be described. The musculature of the right ventricle is much weaker than that of the left and the differentiation into three layers is not so distinct. The middle lamellæ (Fig. 524) also present a transverse course and the deep ones are irregularly oblique and project into the ventricular cavity (see page 175). The musculature of the ventricular septum is derived from both ventricles, but the musculature of each ventricle is independent of that of the other in this situation, and by far the greater bulk of the musculature in the septum

*[A small bundle of fibers, the *atrioventricular fasciculus*, passes from the posterior surface of the right atrium into the upper part of the muscular ventricular septum, in which it passes forward to be lost in the musculature of the ventricles. It consequently forms a connection between the musculature of the atria and that of the ventricles.—Ed.]

is derived from the left ventricle. The uppermost portion of the ventricular septum, that which is formed last, remains membranous and is known as the membranous septum; it is a small indistinctly demarcated area situated between the bases of the posterior and right aortic semilunar valves.

A large number of the muscular fibers both of the ventricles and of the atria take origin from fibrous rings which surround the ostia venosa. These rings (Fig. 527) separate the musculature of the atria from that of the ventricles and serve for the attachment of the valves; they are connected with the intermuscular connective tissue and are designated as the *fibrous (atrioventricular) rings*. The right one is complete and surrounds the entire circumference of the right ostium venosum as an oval ring, while the left one is only three-quarters of a ring,* the anterior portion being wanting where the root of the aorta is fused with the left ostium venosum. This left fibrous ring arises from two small cartilaginous nodules which are situated to the right and left of the root of the aorta and are known as the *fibrous trigones* (right and left).

The *endocardium* of the heart corresponds to the intima of the blood-vessels, with which it is directly continuous. It is rich in elastic fibers and, especially in the atria, contains dense masses of such tissue. It is decidedly thicker in the atria than in the ventricles, being so thin in the latter that the innermost muscular layer of the ventricles and the structures formed by it appear reddish through the endocardium. In the auricular appendages the endocardium is also thin, while in the venous sinuses and throughout the greater portion of the atria it is almost or entirely opaque (Figs. 520 to 523).

The *cardiac valves* (Figs. 520 to 523, and 528 to 531) are formed by duplicatures of the endocardium, and each of the four orifices of the heart is furnished with such a valve which serves to close the opening. The ostia arteriosa are guarded by semilunar or pocket valves which are termed the *semilunar valves*, while those guarding the ostia venosa are known as the *cuspid valves*. Both the aortic and pulmonary semilunar valves are each made up of three segments (Figs. 521 and 522), each segment consisting of a bulging membrane attached to the base of the artery so that its concave surface is directed toward the lumen of the vessel (Fig. 527) while its convex one looks toward the interior of the ventricle. The free or non-adherent margin of the valve is thin and is known as the *lunule;* it is applied against the similar margins of the neighboring segments when the valve is closed, and the center of each lunule is thickened to form a flattened rounded structure, the *nodule (nodule of Arantius)*. During the closure of the valves the three nodules are in contact. The space between each valve and the arterial wall is known as a *sinus (sinus of Valsalva)*.

The atrioventricular valves (Figs. 520 and 523) consist of an endocardial duplicature containing fibrous tissue, and also a few muscular fibers which are derived from the atrial musculature. Their bases are attached to the fibrous rings and they are composed of cusps separated by notches of varying depth; the left valve of the ostium venosum consists of two such cusps, while the right consists of three (Fig. 527). The individual cusps are incompletely subdivided by shallow notches.† The endocardium upon the upper surface of the valve is directly

* The absent fourth is formed by the aortic wall.

† The so-called intermediary cusps are formed in this manner.

continuous with that of the atrium, while that of the lower surface is distinguished by its thickness from the thin endocardium of the ventricle. The lower surface of the valve also receives the insertions of the chordæ tendineæ of the papillary muscles. When the valve is open, the leaflets are relaxed and loosely applied to the wall of the ventricle, but when closed the irregular free margins of all the cusps are in contact and form a shallow funnel-shaped depression directed toward the atrium (Fig. 527).

The inner surface of the cavities of the heart (Figs. 520 to 523 and 528 to 531) is variously modeled. That of the ventricles is almost always irregularly shaped as the result of numerous muscular projections which are of two varieties. One of these appears as long columns of the inner layer of the cardiac musculature, which are connected by transverse fasciculi, covered by a very thin endocardium, and known as *trabeculæ* (*columnæ*) *carneæ*. Their chief direction is parallel to the longitudinal cardiac axis, but they are frequently irregularly arranged.

The second variety of the muscular projections from the ventricular wall are the *papillary muscles*. These are formed not only by the inner, but partly also from the more superficial layers of the cardiac muscle, and are generally much larger than the trabeculæ carneæ and of a conical shape. The base of the cone rests against the ventricular wall, and from its apex thread-like tendons are given off which pass to the atrioventricular valves. These tendons, known as *chordæ tendineæ*, vary greatly in thickness, and subdivide into smaller tendons before their insertions into the cusps of the valves, their insertions always being upon the inferior (ventricular) surfaces of the cusps, and the stronger tendons being attached nearer to the base while the more delicate ones are nearer to the free margin of the cusp. Not infrequently the chordæ tendineæ arise directly from the ventricular wall, from the trabeculæ carneæ, or from the upper portion of the muscular ventricular septum (where trabeculæ carneæ are wanting) without the intervention of papillary muscles. The papillary muscles are usually placed below the interspaces between two leaflets and send chordæ tendineæ to both.

The papillary muscles and trabeculæ carneæ give the ventricular cavity a very irregular shape, since numerous pockets are found between these projections, particularly when the heart is distended. In the contracted state of the ventricle the space between the papillary muscles (the intrapapillary space) completely disappears, so that only the space between the chordæ tendineæ (the suprapapillary space) remains.

The inner surface of the venous sinuses of the atria is generally smooth, but the walls of the auricular appendages, as well as those of the atria, exhibit muscular trabeculæ, resembling those of the ventricles and termed *musculi pectinati* (Figs. 520 and 523).* They are finer and narrower than the trabeculæ carneæ, are more frequently connected by anastomoses, and often pass from one wall of the auricle to the contiguous one. In the intervals between the musculi pectinati the cardiac wall is very thin and transparent, especially when the heart is distended, since the endocardium and pericardium are frequently in immediate contact in this situation.

The Special Description of the Heart.

Having considered the conformation of the heart in general, we now pass to the special description of its individual portions.

* Several authors also term some of these atrial structures trabeculæ carneæ.

FIG. 528.—Frontal section of the heart, especially of the two ventricles. Anterior half seen from behind.

FIG. 529.—Frontal section of the heart, especially of the two atria. Posterior half seen from in front.

FIG. 530.—The cavity of the left ventricle exposed by removing a portion of the wall.

FIG. 531.—The cavity of the left ventricle exposed by removing a portion of the wall. The portion removed is shown in Fig. 532.

THE RIGHT ATRIUM.

The *right atrium* (*auricle*) (Figs. 520 and 529) is an approximately conical cavity, the slightly curved apex of which is formed by the right *auricle* (*auricular appendage*). It is composed of the atrium, the auricle, and the venous sinus. The latter is termed the *sinus of the venæ*

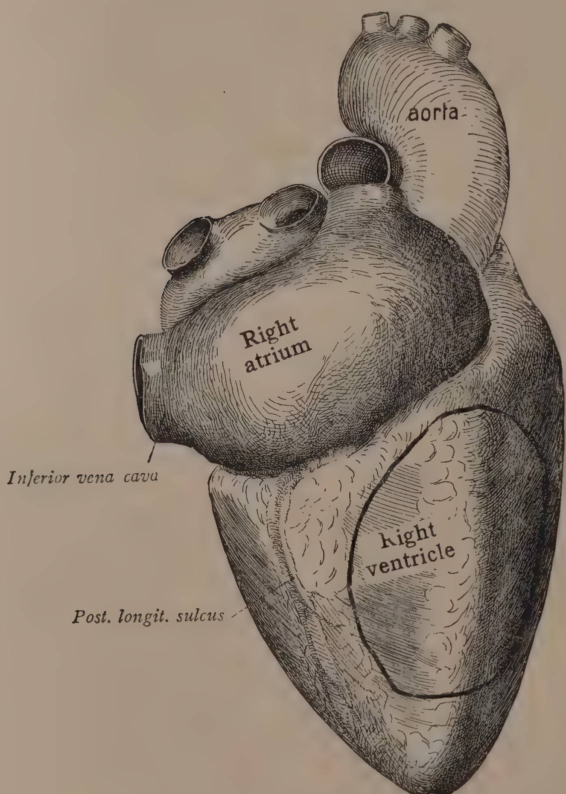

FIG. 532.

cavæ because it receives the two venæ cavæ, and it is separated from the atrium by a muscular ridge, the *crista terminalis*, which corresponds to the *terminal sulcus*. The auricle, on the

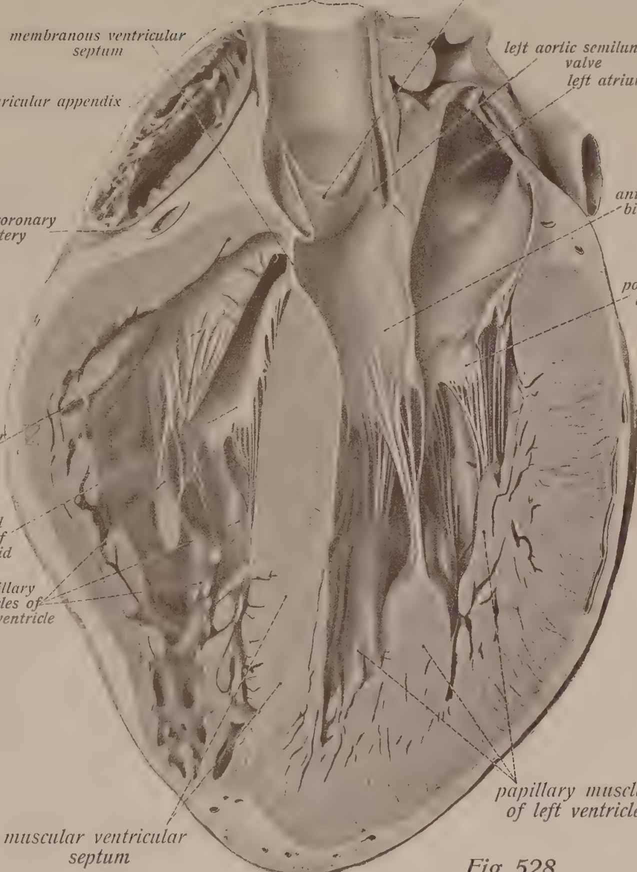

Fig. 528.

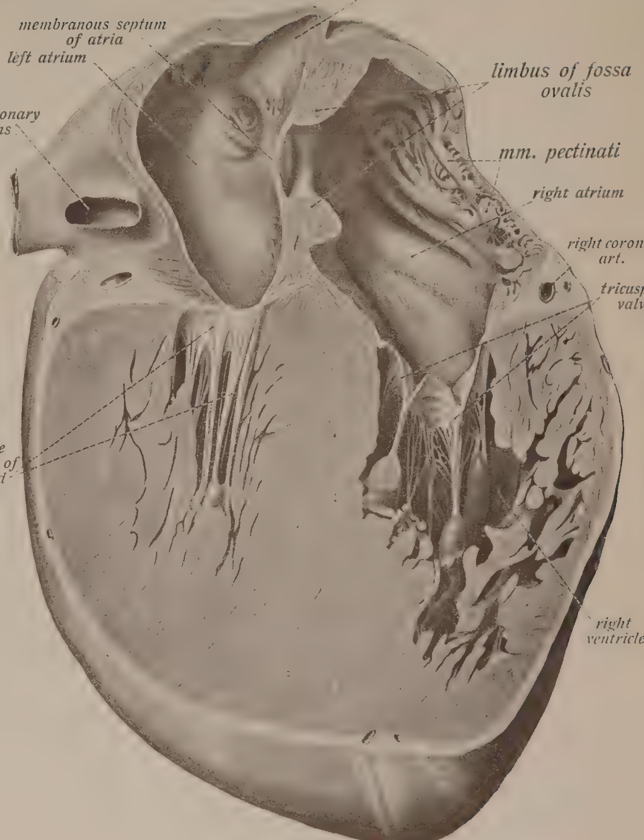

Fig. 529.

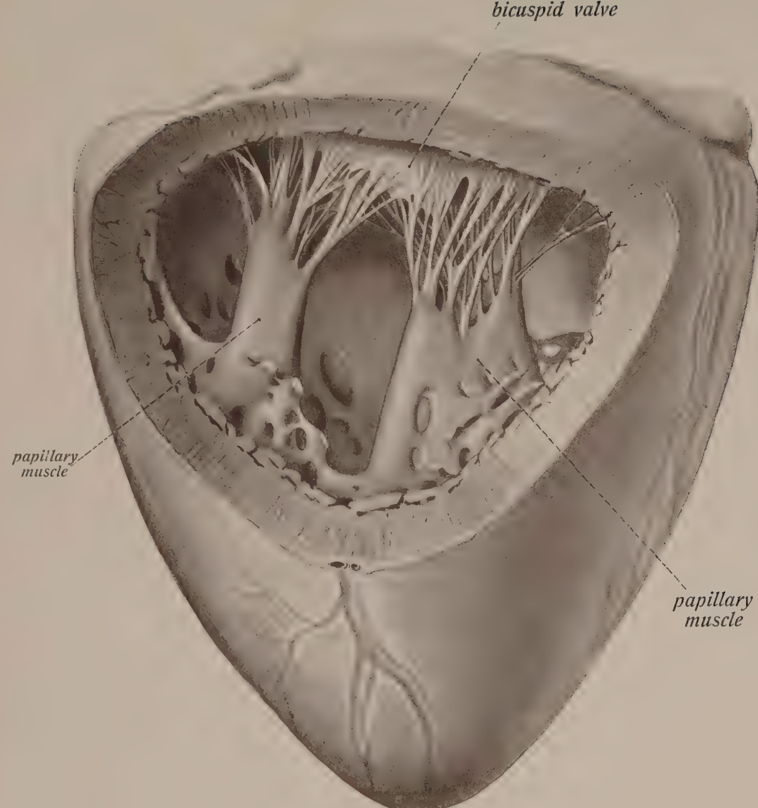

Fig. 530.

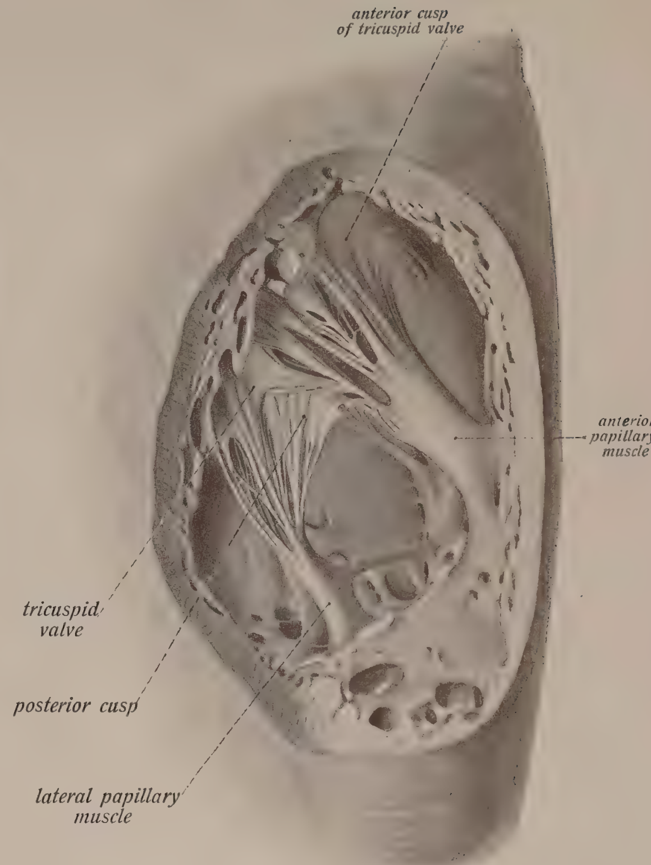

Fig. 531.

contrary, is directly continuous with the atrium, and there is practically no demarcation of the two structures.

The atrium has the shape of a flattened cone and is notched, especially above and below and also at the apex. It embraces the root of the aorta and lies upon the sternocostal surface of the heart in such a manner that its apex almost reaches the pulmonary artery.

The venous sinus of the right atrium receives the superior vena cava above and the larger inferior vena cava below, the orifices of the two veins being opposite each other and their axes forming a markedly obtuse angle (Fig. 520). The two orifices are separated by a distance of about two centimeters and the atrial wall in this situation protrudes slightly and forms the *intervenous tubercle* (*tubercle of Lower*). The orifice of the superior vena cava is smooth, but that of the inferior vena cava possesses an approximately semilunar valve, the *valve of the inferior vena cava* (*Eustachian valve*) (Fig. 520), which in the adult is always riddled with perforations and resembles an irregular network. It is situated between the opening of the inferior vena cava and the right ostium venosum, and its extremity is continuous with the limbus of the fossa ovalis as a long thread.

In addition to the venæ cavæ which empty the blood of the systemic circulation into the heart, the right atrium also contains the orifices of the cardiac veins. The largest of these is the elongated opening of the coronary sinus, which is situated at the junction of the posterior and inferior walls of the auricle, immediately in front of the inner extremity of the Eustachian valve and between the latter structure and the right ostium venosum. The greater portion of this opening is closed by a thin semicircular valve, the *valve of the coronary sinus* (*Thebesian valve*) (Fig. 520), which is frequently perforated near its free margin. The orifice of the coronary sinus is situated in the median plane of the body. The orifices of the smaller cardiac veins, the *Thebesian foramina*, are very small, point-like openings or depressions situated especially on the atrial septum and upon the right wall.

An elliptical or oval portion of the atrial septum is destitute of muscular tissue and is consequently transparent. It is known as the *membranous portion of the septum* and is the site of the fetal *foramen ovale* (see page 169), which usually commences to close at birth. The atrial septum forms the left wall of the right atrium and its membranous portion appears as a shallow depression, known as the *fossa ovalis* (Figs. 520 and 529), which is situated in the lower portion of the septum and is longer from above downward than from before backward. This fossa is surrounded by a muscular ring, the *limbus* of the fossa ovalis (*limbus of Vieussens*), which is particularly well developed in the anterior and superior portions of its circumference. It represents the margin of the original foramen ovale and is plainly visible through the rather thin endocardium in this situation.

The remaining portion of the septal wall of the right atrium is smooth and devoid of musculi pectinati. The latter structures are found throughout the entire auricular appendage and also in the right wall of the atrium, but they are absent in the venous sinus; they consequently commence at the crista terminalis. They extend without demarcation from the right wall into the auricular appendage.

THE RIGHT VENTRICLE.

The *right ventricle* (Figs. 520, 521, 528, 529, and 530) is approximately conical in shape; its relation to the cardiac surface has been previously given upon page 171. The left surface, directed toward the left ventricle, is concave, so that the cross-section of the ventricle is semilunar, and its apex does not extend to the apex of the heart. From the right ventricle the right ostium venosum leads into the right atrium and the pulmonary orifice (the right ostium arteriosum) into the pulmonary artery.

The right ostium venosum is situated in the right and posterior portion of the base of the ventricle. Its fibrous ring gives attachment to the *tricuspid valve*, whose anterior cusp is directed toward the right, and is the smallest of the three, but the most constant in its development. The other two cusps are larger and are termed posterior and internal. The latter is adjacent to the septum and arises from the membranous septum (see page 177). An intermediate cusp is not infrequently observed between the internal and posterior cusps (Fig. 527), or the notch between these two cusps is incomplete and they form a single cusp which is characterized by one or more notches of varying depth.

There is usually one large papillary muscle and a variable number of smaller ones which pass to the cusps of the tricuspid valve (Figs. 521, 528, and 531). The large or anterolateral papillary muscle takes origin from the anterior wall of the ventricle, subdivides into several muscles, and sends chordæ tendineæ to the anterior and posterior cusps. A small papillary muscle frequently proceeds from the postero-external wall and sends chordæ tendineæ to the posterior and internal cusps, and a third and a very small muscle (the internal papillary muscle) is usually present, arising from the ventricular septum at the base of the conus arteriosus and sending chordæ tendineæ to the inner portion of the anterior cusp. Numerous chordæ tendineæ arise directly from the ventricular wall or through the intervention of very small papillary muscles, particularly in the region of the ventricular septum; they are inserted into the internal cusp, but the arrangement of the papillary muscles in the right ventricle is subject to numerous individual variations.

The *pulmonary orifice* (*right ostium arteriosum*) (Figs. 521 and 527) lies in the left and anterior portion of the base of the ventricle, close beside the ventricular septum. It does not proceed directly from the ventricular cavity, but arises from an intermediate conical structure known as the *conus arteriosus*. This is marked off upon the inner surface of the ventricle, especially upon the posterior, internal, and anterior walls, by a slightly elevated ridge, the *supraventricular crest* (Fig. 521). The orifice is guarded by three semilunar valves, which are known as the right, the left, and the anterior valve. They exhibit well-developed lunules (see page 174), but their nodules are but feebly indicated.

With the exception of the upper portion of the ventricular septum, the inner surface of the right ventricle possesses trabeculæ carneæ, although they are feebly indicated in the conus arteriosus, and indeed may be entirely wanting in this situation.

THE LEFT ATRIUM.

The relations of the left atrium to the external surface of the heart have been already considered at page 171. It is irregularly cuboid in shape (Figs. 523 and 529), the left auricular appendage forming a conical prolongation of the anterior wall. The right wall is formed by the atrial septum, the floor contains the left ostium venosum, and at the junction of the superior and posterior walls are situated the orifices of the four pulmonary veins. These latter orifices are rounded openings without valves, and they are so placed that the openings for the two veins of the same side are close together, while the two openings for the veins of one side are at quite a distance from those of the opposite side.* More rarely the two veins of one side open into the atrium by a common orifice or more than two veins empty upon one side. The portion of the left atrium which receives the pulmonary veins is the venous sinus, but as it is usually not marked off from the atrium it is consequently not specifically designated as such.†

In contrast with the right atrium, the septal wall of the left atrium is smooth with the exception of the remains of the *valve of the foramen ovale* (see page 169), and it is frequently invisible. When present it forms a sickle-shaped fold, the free margin of which is directed anteriorly.

The left auricular appendage seems markedly constricted from the remainder of the atrium; it is the only portion of the left atrium which contains musculi pectinati.

THE LEFT VENTRICLE.

The shape of the left ventricle (Figs. 522, 523, and 528 to 530) has been compared to that of an egg, the broader extremity being directed toward the base of the heart, while the more pointed one forms the cadiac apex. Its very thick wall is convex throughout, even in the region of the ventricular septum, which consequently projects toward the right ventricle (see page 178).

At the base of the left ventricle, which is directed toward the right and posteriorly, the left ostium venosum and ostium arteriosum (aortic orifice) are placed side by side.

The left ostium venosum is situated behind and to the left of the ostium arteriosum, and is guarded by the *bicuspid* or *mitral valve*. This consists of an anterior cusp, which is also directed toward the right, and a posterior cusp, which is also directed toward the left. The posterior cusp takes origin from the fibrous ring; the anterior one partly from the fibrous ring and partly (between the fibrous trigones (see page 174), from the posterior circumference of the root of the aorta. The surface of the anterior cusp, which is directed toward the ventricle, consequently passes into the aorta without demarcation. The two cusps are separated by deep notches and are much more distinctly separated than are the leaflets of the tricuspid valve. Two small intermediate leaflets are, nevertheless, occasionally observed.

The mitral valve possesses two large and constant *papillary muscles* (Figs. 523 and 529), one arising from the posterior portion of the left wall and the other from its anterior circumference.

* The orifices of the pulmonary veins consequently form a horizontal quadrangle in the auricle.

† Such a demarcation is justified, however, by the method of development of the heart, since this portion of the atrium originally does not belong to the heart at all.

FIG. 533.—The heart enclosed in the pericardium, seen from in front.
The pericardium has been opened in front.

FIG. 534.—The transverse sinus of the pericardium, seen from the right side.
The aorta and superior vena cava are drawn aside.

Their position corresponds to that of the interspaces between the two cusps (or to that of the intermediate cusps), and they are conical in shape and usually subdivide toward their apices. The chordæ tendineæ given off by these papillary muscles are stronger than those passing to the tricuspid valve.

The *left ostium arteriosum* (*aortic orifice*) is situated anteriorly and to the right, in the region of the base of the heart; it is in front of the anterior cusp of the mitral valve and behind the origin of the pulmonary artery. It is guarded by the aortic semilunar valves, two of which, as in the pulmonary artery, are right and left, but the third is posterior (Fig. 527). They possess well-marked lunules and strongly developed nodules (see page 174).

The ventricular wall throughout possesses well-developed trabeculæ carneæ with the exception of the upper portion of the interventricular septum. The membranous septum is situated between the posterior and the right semilunar valve.

The vessels of the heart will be subsequently considered.

The nerves of the heart are derived from the vagus (cardiac branches) and from the sympathetic (cardiac nerves). They form numerous ganglia within the heart.

The endocardium is formed from the mesenchyme, while the myocardium and pericardium are derived from the cœlomic endothelium of the splanchnopleure. The previously mentioned double rudiments of the heart have nothing whatever to do with its right and left sides, since these are differentiated at a much later period. The double rudiment fuses to form a single S-shaped tube, whose dorsal extremity receives the venous trunks and becomes an atrium, while the ventral extremity is arterial (the *truncus arteriosus*) and becomes a ventricle, these structures being at first single in the embryonic heart. The atrium and ventricle gradually become separated by a constriction which produces an *auricular canal* connecting the two cavities. The first indication of a subdivision into two ventricles is furnished by an *interventricular sulcus*, corresponding to a ventricular septum which gradually grows upward from below, and the truncus arteriosus also becomes divided by a longitudinal septum into two arterial tubes, the subsequent aorta and pulmonary artery. This latter septum grows downward from above to meet the ventricular septum growing upward from below, the communication between the two ventricles persisting the longest at the junction of the two septa, and in this situation there is later formed a membranous ventricular septum.

Later the atrial septum is formed by two sickle-shaped folds, an anterior and a posterior, the anterior fold forming the subsequent muscular septum, while the posterior one represents the valve of the foramen ovale and grows past the anterior fold in such a manner that both folds form the boundaries of the foramen ovale (see page 169). The posterior fold subsequently forms the membranous septum, and the limbus of the fossa ovalis is the lower free margin of the anterior sickle-shaped fold. The valves are also developed at this time, and the orifices of the veins form the venous sinuses of the atria.*

THE PERICARDIUM.

The *pericardium* (Figs. 414, 451 to 455, 457 to 462, 533, and 534) is a fibrous sac which contains a serous cavity, and consequently a fibrous and a serous pericardium may be recognized. The parietal layer of the serous sac is so intimately adherent with the fibrous pericardium, however, that the two structures together are known as the pericardium, while the visceral layer, which

* In a book of this character only the chief features of the development of the heart can be given. For further details the reader is referred to the text-books of embryology.

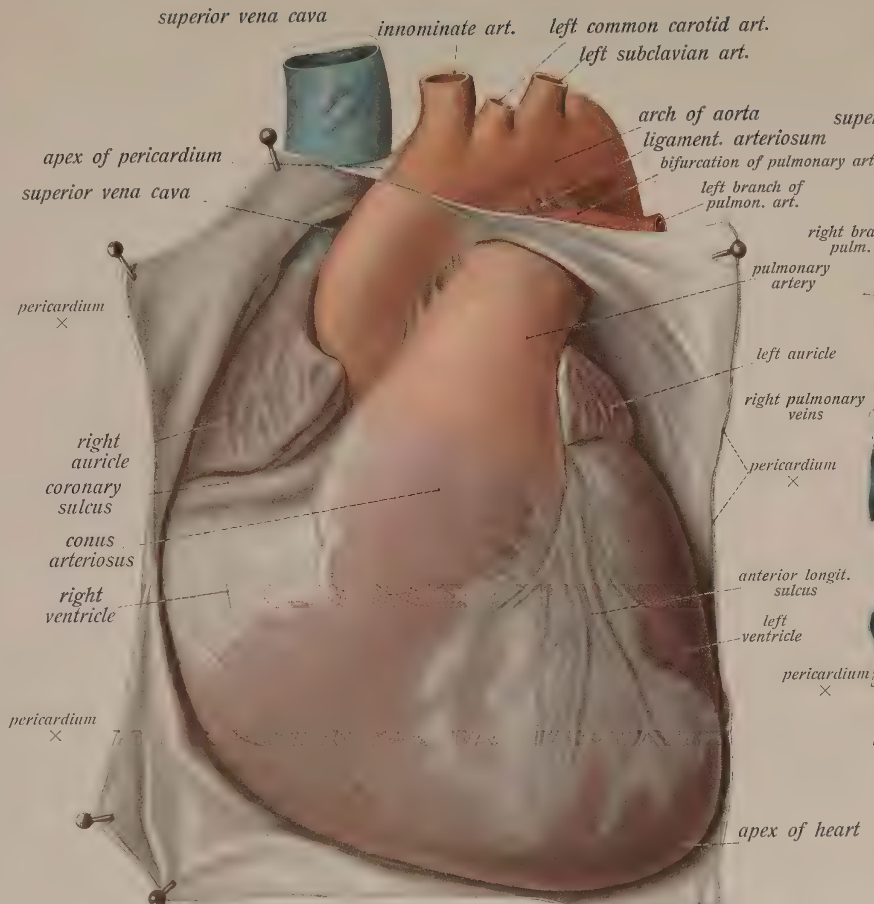

Fig. 533.

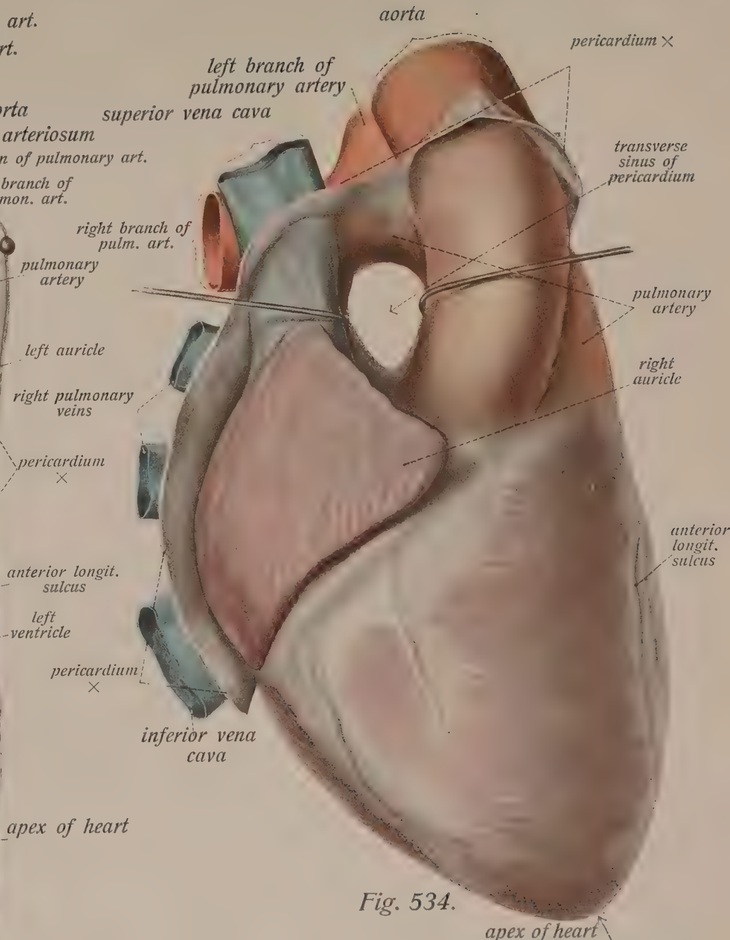

Fig. 534.

invests the heart and the portions of the great vessels within the pericardial sac, is known as the epicardium (see page 172).

The pericardial sac is conical in shape (Figs. 452, 461, 462, and 533), the base of the cone being directed downward and firmly adherent to the tendinous center of the diaphragm, while its apex is directed upward and is adherent to the wall of the aorta at the junction of the ascending aorta with the aortic arch. The entire ascending aorta consequently lies within the pericardial cavity (Fig. 534), which also contains the pulmonary artery up to the site of its bifurcation and the small portion of the inferior vena cava situated above the diaphragm. That portion of the superior vena cava which is below the entrance of the vena azygos is also included within the pericardial sac, but the epicardium extends higher upon the anterior surface of the vessel than upon its posterior surface. The pulmonary veins are within the pericardial cavity almost up to their points of exit from the hilus of the lungs.

The vessels pass through the pericardial sac in such a manner that the fibrous layer of the pericardium adheres to the wall of the vessel at its entrance into the sac, while the serous layer is reflected upon the vessels as the visceral layer or epicardium (Figs. 533 and 534). This reflection of the parietal into the visceral layer takes place only in two situations, however, and not upon each of the eight vessels passing through the pericardial cavity. The two arteries, connected by fibrous tissue, have a common epicardial sheath, and in a similar manner the parietal layer is reflected as epicardium upon the atria and their afferent veins. There is thus formed a broad transverse foramen which is bounded anteriorly by the arteries and posteriorly by the atria and the superior vena cava (Fig. 534); it is known as the *transverse sinus* of the pericardium, and in the adult is large enough to admit three or four fingers. Deep pockets also occur between the atria and the points of exit of the individual veins, especially between the left pulmonary veins and the left atrium.

The shape of the pericardial cavity is that of an isosceles triangle. From the base, which is attached to the diaphragm, the short right side passes almost vertically upward to the apex, while the longer left side pursues an oblique direction. The anterior surface of the pericardial cavity lies behind the sternum and the costal cartilages, to which it is connected partly by loose connective tissue and partly by stronger fasciculi, known as the *sternopericardiac ligaments*, and in the child the thymus gland (see page 107) covers a considerable portion of this surface; in the adult, however, only the remains of the thymus are to be found. The lateral surfaces of the pericardial cavity are in contact with the pericardiac pleura (see page 112); the posterior surface forms the anterior boundary of the posterior mediastinum (see page 110) and is rather firmly connected with the œsophagus and the aorta.

A small portion of the anterior surface of the pericardium lies to the left of the sternum in the region of the attachments of the fifth to the seventh costal cartilages and the intervening intercostal spaces, and is immediately behind the anterior thoracic wall without a pleural covering (see page 110).

The pericardium together with the heart is in contact with the following organs: with the lungs, producing the cardiac impression in each viscus; the base is in contact with the diaphragm and indirectly with the liver and stomach; the apex is in relation with the large vascular trunks above the heart and also with the thymus gland and the œsophagus.

In the upper portion of the posterior wall of the pericardium between the left superior pulmonary vein and the base of the left auricular appendage is situated a fold which gradually disappears upon the posterior wall of the left auricle. It is known as the *fold of the left vena cava,* since it corresponds to the embryonic left superior vena cava, which is subsequently obliterated with the exception of the portion forming the oblique vein of the left atrium.

The serous cavity of the pericardium is filled by a somewhat larger quantity of fluid (several cubic centimeters) than is usually observed in serous cavities in general.

INDEX

American Text-Book of Pathology

American Text-Book of Pathology. Edited by LUDVIG HEKTOEN, M. D., Professor of Pathology, Rush Medical College, in affiliation with the University of Chicago; and DAVID RIESMAN, M. D., Professor of Clinical Medicine, Philadelphia Polyclinic. Handsome imperial octavo, 1245 pages, 443 illustrations, 66 in colors. Cloth, $7.50 net; Sheep or Half Morocco, $8.50 net.

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